

THE BEHAVIOR OF THE NEWBORN INFANT

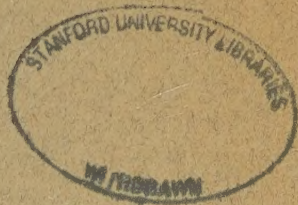
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THE DEGREE OF DOCTOR OF PHILOSOPHY IN THE GRADUATE
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BY

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These investigations were started in 1925. Dr. Eugene F. McCampbell placed the resources of the Starling-Loving Hospital at our disposal, and Dean J. H. J. Upham is now extending us every facility to continue the work. It can be readily understood that an investigation of this kind interferes somewhat with hospital routine, and we wish to express here our hearty appreciation of the assistance given by Dr. S. A. Hatfield, and Mr. Charles E. Findlay, Superintendent of the Hospital, by Miss Mabel Ickes and by Miss Frieda Schacht, supervising nurses, and others of the hospital staff.

Our co-workers were Miss Dorothy Postle, Miss Dorothy Palmer, assistants in psychology, Mr. Orvis C. Irwin, instructor in psychology; and Miss Mary Christine Gatewood.

For the many administrative details we are indebted to Dean George F. Arps of the College of Education and Head of the Department of Psychology. From the first he has shown a very active and personal interest in the investigations.

It is difficult to assign the credit for the different sections of the monograph. Dr. Pratt was the first to start the experiment. The section on the general historical approach, study of the plantar reaction and the preliminary experiments on light, sound, thermal stimulations, the reactions to holding the nose and arms, the study of the control period, and the construction of the original apparatus are his work.

Dr. Nelson contributed the sections on experimental technique, reactions to taste, smell, temperature. Dr. Sun contributed the sections on reactions to light and sound; he wrote the descriptions and made the drawings of all the apparatus, assisted in the preparation of the data, and in the coördination of the different sections of the monograph.

There are, of course, many others to whom we are indebted. The general interest in a problem of this type brings valuable suggestions from many sources both within and without the group of investigators actually performing the work.

A. P. WEISS
ANDREWS ROGERS



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PREFACE

As fundamental to these investigations we assume that the human infant at birth is a biological organism and that he becomes a coöperative unit in a social organization as the result of (*a*) his genotypic inheritance, (*b*) the effects of prenatal and postnatal conditions during the physiological development of his sensorimotor system, and (*c*) the external physical stimuli which begin to act at birth and continue to act throughout life. Of the external physical stimuli those which have a social origin may be designated as the social inheritance. It is assumed that the most complex adult behavior represents some modification of infant behavior. It may be exceedingly difficult to trace the successive stages in the development of any specific form of behavior and to isolate the stimulating conditions which produce the modifications, but a complete understanding of human behavior requires such an analysis.

We have assumed further that infant behavior may be studied in the same way as any of the objects (and relations between objects) which form the subject matter of the natural sciences. From this standpoint, infant behavior consists of a series of movements which can be classified according to their physical and social components.

Every reaction modifies the nervous system of the infant so that no two reactions are identical, even in the same infant. This is true even though they are reactions to physically identical stimuli. Theoretically this would make it impossible to classify infant behavior. For practical purposes, however, it is possible to group the reactions into classes, and it is possible to describe and control the stimuli without which the reactions do not occur. It is assumed that human behavior can be studied scientifically as the product of internal and external changes without introducing a special *mental* entity.

The general results of our investigation seem to show that the infantile sensorimotor equipment at birth is not nearly so specific as has been supposed. With the exceptions that will be noted in the appropriate places, we may say that for the human

infant any reaction may occur to any stimulating condition. Specificity develops with growth and in response to the social environment. We have not found at the early ages of our subjects, all the reflexes, instincts, defense reactions, rage, love, and so forth, which have been described by other investigators. Infantile behavior is not merely a simplified form of adult behavior, nor is adult behavior merely a complication of infant reactions. The amount of modification in behavior between infancy and social maturity, has been greatly underestimated.

We do not seem to have in the newborn infant nearly so many specific responses to specific stimuli as is the case with infra-human forms. From the very beginning, the behavior of the human infant is much more changed by the physical and social environment than that of the young of any other species; herein the difference between them seems to lie. This does not imply that the inheritance component is any weaker. It does imply that the inheritance component is more varied. Of the more complicated forms, perhaps the most uniform inherited reaction is that of sucking, but if this sensorimotor mechanism is observed for the *variety* of its manifestations rather than for its uniformity, it is found to occur with all forms of stimulation and is accompanied by many other reactions. Of course, while all infants who survive make adequate sucking reactions, the differences between infants, and for the same infant at different times, show such a strong effect of external and internal stimuli that we have found it impossible to isolate the inherited factors in even so simple a sensorimotor mechanism as that of sucking.

There is at present no adequate technique for studying the inheritance component in infant behavior. That it is present, no one who has observed the individual differences between infants, will deny. However, just what movements are indicators of certain inheritance elements, we do not know. In our observations we have listed about one hundred and fifty specific movements. It is possible that certain combinations of these may give an index of the type of inheritance. But until we are able to observe the development of many individuals from infancy to some degree of maturity it is hopeless to try to isolate the inherit-

ance factor. It is reasonably certain that the categories which distinguish widely differentiated adult forms of behavior such as rage, love, and fear are not observed in the newborn infant. However, much of the current denial of the existence of inherited forms of behavior is due to the fact that the adult categories of behavior are used as a basis for hypothetical classifications of infant behavior. At present it is only safe to say that a genotypic inheritance factor is present even in infant behavior, but there is still a great deal to learn before we shall be able to make practical applications in the training of infants.

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CHAPTER I

INTRODUCTION

THE PROBLEM

It is assumed that the infant starts as a fertilized ovum made up of a number of complex but specific chemical compounds. The course of their interaction will depend not only upon the compounds themselves, but also upon the substances with which they are surrounded. The earliest stages in the development are the ones in which the changes seem to be greatest. In the pre-natal stage the organism passes rapidly from the unicellular type of protoplasmic organization to the multicellular type. At birth he becomes independent of his mother with respect to respiration and digestion. Within two years he has acquired independent locomotion and has begun to acquire those verbal reactions which make him a unit in a compound multicellular or social organization. Not until years afterward can he provide or contribute much to his own protection or maintenance. To understand the individual as a social unit, it is necessary to study his ontogenetic development. This should include the embryological stages, but at present these require for their study a technique and method which is relatively distinct from that required for the study of infant behavior; and we have arbitrarily begun our studies at the period immediately after birth (from one to four hours).

The problem of these investigations is that of (*a*) determining the reactions at birth to certain stimuli, (*b*) following the ontogenetic development of these reactions, (*c*) noting the emergence of new reactions, within the time limits of about two weeks. This is not a sharply defined physiological period, but it is the only period in a child's life, up to the school age, in which children in unselected groups are readily available for study. The further extension of investigations into the nursery is now beginning to be recognized as an important approach to the study of the development of adult behavior.

In making this investigation, it has been found necessary to design and construct apparatus to secure controlled stimuli, and

also to secure a permanent record of the changes in posture, either as the result of unknown external and internal stimuli (so-called spontaneous activity), or those due to the experimental stimuli. Quantitative values have been secured wherever possible, and when only qualitative descriptions were available these have been statistically assembled into quantitative form. Every effort has been made to present the experiments and the data in a way that will enable others to repeat them. We recognize our own shortcomings in this respect, but we only claim to have made a beginning. Our conclusions are provisional. As soon as a given reaction is studied intensively, with, say, eight or ten variations in stimulus intensities, all of the experimental period (which cannot exceed two hours in duration) must be devoted to a single form of stimulation. Before attempting intensive study it was decided to get first, the reactions to a number of *different* stimuli, leaving for the future the more intensive investigation of a single form of stimulation.

Simply stated, our final problem is that of determining how the infant becomes the adult who participates in and contributes to the complex civilization which the zoölogical species *Homo sapiens* has built up. Our specific problem in this monograph is to describe infant reactions as the products of those forces and structures which form the subject-matter of the natural sciences. We have avoided those categories of traditional psychology which assume that there is some psychical factor operative in the development of human behavior.

GENERAL HISTORICAL APPROACH

Interest in the behavior of the newborn child is of comparatively recent origin. Ancient historical documents, particularly those dealing with medicine, give very little information regarding the care of the child either in health or disease, and there is little or no mention made of the significance of the behavior, which is now considered as indicative of the subsequent habits which the individual will acquire. The old legal and medical codes merely specified somewhat meagerly as to food and clothing, and more insistently as to religious rites, notably the circumcision of males.

Beyond noting the resemblance between the behavior of some animals and that of young children and thus indicating some relationship between genetic and comparative psychology, the Greeks, so fertile in other fields, failed to give much attention to the child. The speculation as to the relation between mind and matter in its applications to the newborn child was reserved to later generations of philosophers and scientists.

The development of child study in all its aspects is largely a development of the past one hundred years. Its growth, in the form of what has sometimes been termed the cult of the child is of even more recent date.

A survey of the vast literature on child study reveals four principal methods in the study of infantile behavior. Rarely is one method employed to the exclusion of the others, and the classification is therefore more or less arbitrary and justified only if one is to present a historical account of the general trends of the investigation of infantile activity. These methods are: (1) the speculative method; (2) the biographical method; (3) the statistical method; (4) the experimental method.

METHODS OF STUDYING INFANT BEHAVIOR

The Speculative Method.—The speculative approach, as is to be expected from the lack of anatomical and physiological data, is the first to be evolved and is most universal since it requires a minimum of training, careful observation, and effort. The degree of detachment from the child itself may range from literary reminiscences supplemented by superficial observation, to a careful study of individual children with the end in view of collecting data not for the sake of the data but in order to infer from them the beginning and development of mind.

The philosophers' contact with the young child was very casual. Many even presumed to lay down pedagogical principles without ever having observed children at close range. Aside from the development of pedagogical principles, philosophers were largely preoccupied with abstruse questions, such as, for instance, the exact time when a new individual acquired a soul. This in later times reappears in conjectures as to the ontogenetic appear-

ance of mind. Rousseau, as reported by Claparede (1905), was one of the first to suggest that the child itself be made an object of study and that the results of such study only would furnish a genuine basis for pedagogical theories.

Reconstruction of the child or infant mind has ever been a favorite theme of the literary writer. Even literature may be classified as subjective or objective according to whether the author gets behind the scene and introspects for his characters be they human, subhuman, or even inanimate, or whether he records verifiable observations. The objective method in literature is known as realism. The realists have not been concerned with the newborn child but there are many famous accounts in the works of the subjective school of the supposed *experiences* of young infants. The method is simple. The adult in retrospection upon his own life recalls his *earliest experiences* and attempts to infer from unsystematically observed infant behavior the difference between the infant and the adult mind.

The most common assumptions of writers of this type are that the infant confronts the extra-uterine world with profound terror and that the miseries of existence far outnumber the joys. In other words, for the newborn child, pain is the prevailing and predominating experience. The literary man is joined in this questionable speculation by many investigators, particularly those pioneering in the field of genetic psychology, who for the most part give a fairly accurate description of infants' overt reactions.

T. Lucretius Carus, in his poetical exposition of Epicurean philosophy, the famous *De Rerum Natura*, compares the newborn babe to the shipwrecked sailor tossed naked, speechless, and deprived of the necessities of life, upon the shore.

Similar interpretations of the nature of the child may be found in the works of Anatole France, particularly in *Le Livre de Mon Ami*, and in Rolland's *Jean Cristophe*. In the latter we find the newborn babe endowed with hallucinations, the capacity of experiencing fright at shadows, seeing phantoms, feeling pain, being soothed by the music of the chimes, dreaming of shapes fantastic, and so on. It is, however, not within the scope of this monograph to present a comprehensive survey of this non-scientific material.

The Biographical Method.—As its name indicates, this method of child study consists in jotting down, day by day, the observed changes in the infant's behavior. The main prerequisite for such research seems to have been that the investigator raise a family.

There is no doubt that this offers a particularly good opportunity for tracing the genetic development of a particular child. It permits many observations each day and enables one to follow the child's consecutive development through a number of years. As a matter of fact, practically all our knowledge of the first two years of life has been attained in this fashion. Only in the past few years have there been any studies of the pre-school child, and even these begin at about the age of two. This method, perhaps, gives a better idea of the development of the child as a whole than do the other types of investigation.

There are a score or more of these biographies, the classical examples being those by Pestalozzi, Darwin, Preyer, Perez, Shinn, and Major. Of these, that by Preyer (1881) is by far the most significant. In fact, it is so detailed and exhaustive that all his successors have made use of it as their source book.

Preyer traces the genetic development of the reactions to sound, smell, taste, visual, auditory, contact, and like stimuli from the first to the fortieth month of life. In the same manner he treats of reflexes and instincts. The development of language reactions is followed from the very beginnings. In short, he has sought to give a complete picture of the behavior of the child during the first three years of life.

Another example of the biographical method is the detailed account of the development of her niece, reported by Miss Shinn (1893-1899-1900). While many of the inferences which infant biographers draw from the behavior of infants now seem unwarranted, yet the studies present a fairly accurate account of infant behavior.

The biographical method is open to two criticisms. First, it does not make sufficient allowance for individual differences (particularly if one attempts on the basis of one child's behavior to generalize about all infants); second, the attitude towards the infant will, on account of the relationship existing between it and

the experimenter, be too personal, too biased. The disadvantages are all sufficiently serious to warrant the belief that this method has outlived its usefulness.

Statistical Method.—Just as the systematic biography represents a step forward from untrained and casual observation so does the collection of data upon a great number of cases represent an advance over the biographical approach to the problem of infantile behavior. This method has the advantage in that it furnishes a better notion as to just what the central tendency in any specified form of behavior really is. It is not so likely to produce the widely divergent statements found in the biographical accounts of a few infants.

In the second place, it means a step forward in control. Most of the researches of this type have been conducted in maternity hospitals where environmental and experimental conditions are much more constant. All infants are tested under more uniform conditions. Since these investigations are made in the hospitals, access is most easily available to members of the medical profession, and almost without exception these studies have been made by physicians. This insures, due to the physician's type of training, a much more accurate and much more scientific description of infantile behavior. Furthermore, since no consanguinal ties are present, the observations are more impersonal and unbiased.

One of the disadvantages of most of the studies thus far made, although it is by no means inherent in the method, is that tests are made of the infants available and the results checked off against the age, no attempt being made to secure consecutive tests upon the same infant over the period of time the child is available in the hospital. It is not argued that this invalidates the results of these investigations. It is merely urged that perhaps new facts might come to light if the genetic development of each of the infants were followed.

The statistical method has been employed in studies both of general and specific forms of behavior. One of the earliest of these was that made by Kussmaul (1859). It was carried on in a maternity hospital and was devoted to determining the reactions of the newborn child to touch, taste, smell, vision, and

audition. Genzmer (1873) reports work of the same nature. The work of Kroner (1881) also belongs to this class. Of the statistical papers in recent years, that by Peterson and Rainey (1910) represents one of the most ambitious investigations made. The reactions of over one-thousand newborn infants to thermal auditory, visual, contact, taste and smell stimuli are tabulated. Unfortunately the material is badly organized and no numerical values or constants are available.

The studies made by Watson (1919) and his pupil Blanton, are important largely because of the objective attitude which is maintained. While these investigations extend over most of the overt behavior of the child and also treat of the more complex types of behavior in addition to the simple reactions, the data are too few for establishing the generalizations which the writers (especially Watson) have made from them.

By far the best investigation made to date is that of the Shermans (1925). They limited their study to the investigation of the pupillary reflexes, eye coördination, reaction to the prick of a needle, coördination of arms, and the plantar reflex. The reaction values are plotted against the age (in hours), and correlations and probable errors are given.

Most of the studies upon special reactions which are valuable are of the mass investigation type. The results are stated in percentages, and the time in weeks and days rather than hours.

Experimental Method.—This method stresses the control or accurate measurement of the stimulating conditions, and a careful recording of the actual movements that are made. For the newborn child this method is one for future investigations.

As pioneers we may mention Bechterew (1908), who used the experimental method of recording the breathing and fontanelle pulsations of newborn infants in studying the simple reflexes. He used a small sensitive balloon which he placed under a cap covering the fontanelle. Canestrini (1913) studied the circulatory and respiratory reactions by adjusting to the large fontanelle of the infant a modified Marey pneumograph, and by placing another small pneumograph on its abdomen. An electric watch was used which indicated half-seconds. The curves were traced upon a

smoked drum by means of small markers. The complete record contained tracings of the pulsations of the fontanelle, breathing records, the time line, and finally the time of stimulation. Only full-term infants were used, and only those were selected which had large and pulsating fontanelles. The experimentation covered a period of three years, 70 infants were examined, the study yielding 200 records which contained 700 individual experiments. The stimuli used were visual, auditory, tactual, olfactory, and gustatory. Canestrini criticizes early authors for limiting themselves to the mere observation of the facial expression of the infant, its gross bodily movement, and the various reflexes which are released by stimulation. When these bodily activities are further interpreted as expressions of psychic experiences, Canestrini believes that the investigator lays himself open to particular criticism. He quotes Bechterew (1908) as saying, that it is impossible to get a true picture of an individual's subjective experiences by observing his facial expressions, his gestures, movements, language, and other objective signs of his neuro-psychic activity. Canestrini adds that this is true not only of adults but also of children.

It is obvious, he says, that the occasional mimetic expressions, the movements, the undifferentiated vocal expressions, cannot present a complete picture of the child's psychic experiences, because of the undeveloped nervous system. To suppose that they do leads to the conflicting results reported by the various authors. He calls attention also to the fact that the facial expressions of the infant show very few variations.

Peiper (1924) reports experiments in which he used as his subjects three premature infants. He does not state the length of the period of gestation. One was three days old, the other two were each fourteen days old. His method was that of recording breathing changes on a kymograph. A small bag was placed upon the infant's abdomen, and a tube led from this to a Marey pneumograph marker. A second marker indicated the instant the stimulus was given, and a third marker recorded fifths of a second. A tracing was always taken first of the breathing without stimulation, since the breathing of premature infants is more irregular than that of normal full-term infants. The problem

was to see whether or not there were changes in the breathing curves as the result of stimulation. All of the experiments were performed while the infants were asleep. It was found that when the stimuli followed too closely upon one another no reaction was released for any except the first stimulation. Consequently a longer interval was introduced between the various stimuli. The length of this interval is not given. He used a rather novel device to study the reactions to temperature changes. A small bag was placed upon the abdomen of the infant. To it were attached two tubes, one receiving the cooled water, the other serving the purpose of a drain. In this way the contact remained the same and only the temperature was changed.

This short review of the methods of investigating infant behavior serves to show that there has been a gradual development and growth of this kind of investigation, and also that the methods of investigation are gradually becoming more and more exact. It is a long step from the speculations of the philosopher regarding "the beginnings of the mind" in the newborn—speculations which did not even necessitate the presence of the infant—to the rigid experimental technique of such experiments as those reported by Canestrini.

A more detailed consideration of the experiments reported in this general historical approach will be given under the appropriate stimulus and reaction headings. Such a careful review as that of Peiper (1928) shows the weakness of our methods. Nearly every statement about infant behavior can be matched with one that is contradictory. This is not due to the contradictory nature of the *facts* that are observed, but due to poor methodology in the investigations.

In general, it may be said that hospitals are beginning to welcome careful experimentation. Much of the work done in Europe has been done by men in the medical profession. In this country, psychologists have taken the lead in investigating infant behavior, the medical men reserving as their field of investigation the problems of more strictly anatomical and physiological import. It is much to be desired that the two professions coöperate in solving the important problems of infant behavior.

No attempt has been made to report the excellent researches that have appeared within the last five years. However, no one familiar with recent infant research can help but notice the more scientific character of these studies. The next quarter century will tell a different story from that of the quarter century which has passed.

GENERAL APPARATUS

Even the relatively standardized conditions in the nursery of a hospital maternity ward are hardly uniform enough to carry out experiments with young infants. The varying lighting conditions, the many sounds, the variations in temperature and humidity, introduce external stimulating conditions which complicate the reactions to the experimental stimuli.

In order to eliminate some of these variables, an experimental cabinet was built, in which the infant was placed. In this section only the general apparatus is described. The special apparatus for the different stimuli is described under the sections dealing with particular results.

THE EXPERIMENTAL CABINET

The cabinet unit consists essentially of a large box, or experimental control chamber, mounted upon rubber-tired heavy-duty casters. The chamber is made of double-walled composition-board sections. The top and bottom sections are supported on 38x38 mm. framework and the other sections are bolted to this. The external dimensions are 80 cm. wide by 140 cm. high by 150cm. long. The chamber rests upon a caster carriage 44 cm. high.

The walls are composed of two 6 mm. sheets of composition board with a 25 mm. space between packed with sawdust.

To provide light-proof joints the edges of the sections were tacked with strips of soft cardboard matting. The walls are painted white on the outer surfaces and dark brown on the inner surfaces.

The details of the external sections are indicated by the symbols shown in Fig. 1.

I. A wooden switch-box 48 cm. x 14 cm. containing the relay of the thermostatically operated heating unit, main switch, fuse, polygraph motor socket, light and signal switches.

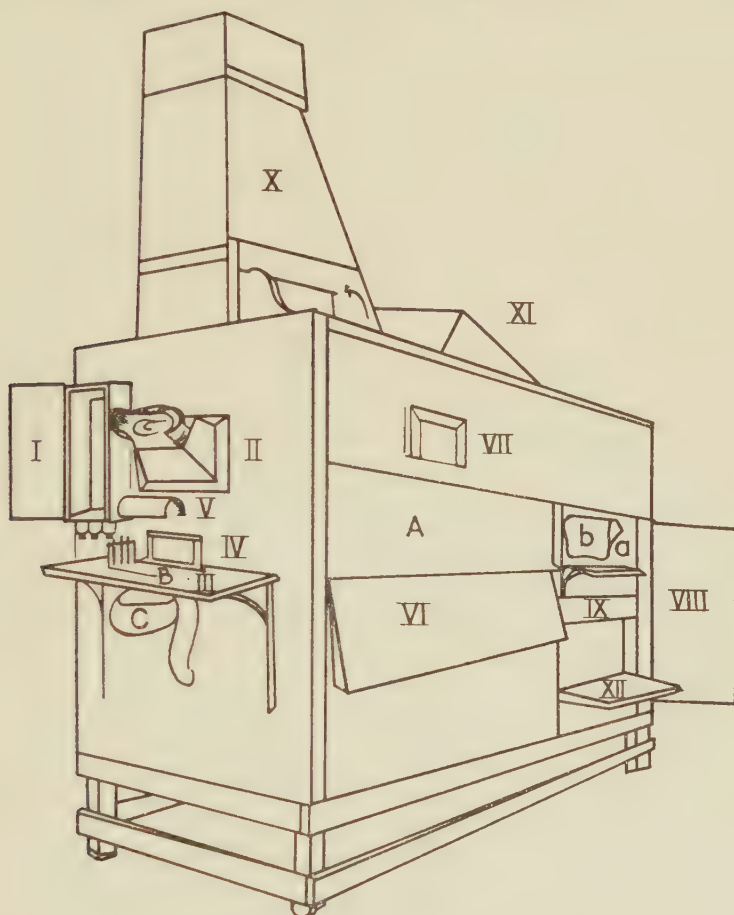


FIG. 1. External view of experimental cabinet.

II. A window 20 cm. x 15 cm., attached to which is an observational head-piece similar in shape to that of a stereoscope. Through this the recorder watches the movements of the infant and the experimenter, and records the reactions and the time

at which the stimulus is applied on the strip of paper which is part of the recording unit.

III. A wooden shelf 60 cm. x 39 cm. which carries the recorder unit (B) and the motor (C) that runs the polygraph. The details of both C and B are shown in Fig. 2.

IV. A pen-rack for the recording pens when not in use.

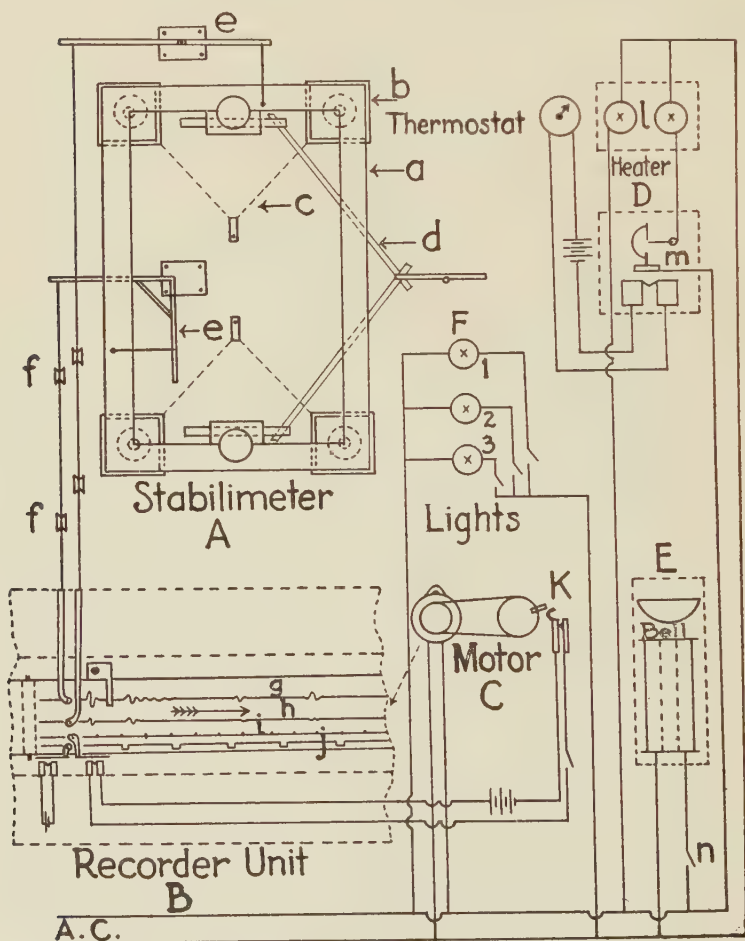


FIG. 2. Wiring diagram of cabinet units showing relations between stabilimeter, polygraph, recording motor, heater, thermostat, electric stimulus bell, etc.

V. A lamp shade with a 25-watt Westinghouse frosted blue bulb providing illumination for the recorder to make notations on the polygraph record.

VI. A horizontal hinged drop door 28 cm. x 105 cm. for introducing the infant into the cabinet and placing him on the stabilimeter shown in detail in Fig. 2.

VII. Another window, without an observational head piece but provided with a shutter, 20 cm. x 15 cm. for the experimenter to watch the infant during the control period, and to coöperate with the recorder in securing uniformity in reporting movements.

VIII. A vertical door 45 cm. x 92 cm. swinging out from the box to provide room for the shelf-door.

IX. A vertical shelf-door 45 cm. x 92 cm., swinging within the cabinet. This door has two permanent shelves.

(a) A wooden shelf, 18 cm. x 44 cm. which carries the protocol strip on which the experimenter records specific reactions or a general description of the infant during the experimental period. This strip is the same as the polygraph record and is usually rolled in with the polygraph record. A simple holding device keeps the paper flat and as more space is needed it is unrolled and a new surface exposed.

(b) A lamp-shade with a 25-watt frosted blue lamp which provides illumination for the experimenter's protocols.

X and XI are the supports for the camera and mercury vapor lamp for taking moving pictures of the infants.

XII. Another shelf 18 x 44 cm. permanently attached to IX, providing space for the flashlight, slides, smell applicator, and other necessities which should be within easy reach of the experimenter.

WIRING DIAGRAM OF CABINET UNITS

A. Stabilimeter. This is located within the cabinet. It consists of a light fiber platform 65 cm. x 46 cm. x 3 mm. (not shown in the diagram), mounted on roller bearings (*b*) at the corners, and held in a neutral position by the four springs (*c*) pulling from the corners toward the center. When the infant moves, the platform "wobbles" and these motions are transmitted by strings and the levers (*e*) to the two recording pens (*g*, *h*) of the

recorder unit B. Movements in the head-foot direction are recorded by one pen, movements toward right or left by the other. It is the movement of this platform which forms the basis of the reaction measures given in the data.

(a) Frame of stabilimeter 46x31x1 cm. made of poplar wood.

(b) Brass plates at corners which form the bearings upon which the balls roll. Size of plate 65x65x3 mm. thick. Roller bearing balls 20 mm. in diameter. These bearings are surrounded by a 25 mm. fiber ring which keeps them from rolling off the bearing plates.

(c) Springs, of which there are four and which counter-balance each other. Size of springs 12 cm. long, 2 cm. in diameter, close wound from No. 20 gauge music wire.

(d) Locking device for holding platform while putting on or taking off infant, or when it is necessary to touch infant in applying stimulus. When the locking device is set, the movements of the infant are not recorded by the stabilimeter pens.

(e) Light wood levers for transmitting movements of stabilimeter platform in the proper direction for the recording pens. Size: right-left lever arms 15 cm. and 16.5 cm.; head-foot lever arms 11 and 6.5 cm., made of poplar wood 1 cm. wide and 4 mm. thick. The lever arms are so attached that there is some magnification of the pen movements.

(f) Small grooved brass pulleys on swivel arm used to adjust the length and tension of the cords which transmit the motion.

B. Renshaw-Weiss (1926) recorder unit.

(g) Recording pen for right-left movements of the infant.

(h) Recording pen for head-foot movements of the infant. Each pen is held in its proper position by a steel guide rod 2.5 mm. wide and 2.5 mm. thick sliding in grooves and held under tension by a spring. The record of the pens traces deviations above or below a central (rest) position. In this way it is possible to calculate the direction of movement; whether to the right, or left, or toward head or foot of the infant.

(i) Stimulus marker. This can be used either by the recorder, or by the experimenter, or by both.

(j) Time marker. In addition to tracing a time line this marker gives a weak auditory click at regular intervals. These clicks serve as an easy method of calibrating the rate of movement of the paper tape by an ordinary watch, and also as a convenient auditory stimulus for the experimenter in regulating the time between successive stimulations. We found an interval of 4.5 seconds best for all purposes.

C. A constant speed, alternating current, governor regulated motor which drives the paper tape under the pens. The auditory time signal contact is shown at (k). The number of contacts can be varied from 1 to 5 seconds.

D. Heater and Thermostat. The heater in the cabinet is an ordinary 660 watt A. C. "Cozy Glow" Westinghouse heater. The thermostat is a "Marvel" instrument used for regulating room temperatures. It varies 1° F. above and below its setting. We found it necessary to place two 150 watt lights (*l*) in series with the heater so as to get a constant gentle heat rather than the surges which are produced when the heater is used without the additional lamp resistance.

(*m*) Relay in series with thermostat and two dry cells. This makes and breaks the 110 V., A. C. current passing through the heater.

E. One stroke A. C. electric bell used as a sound stimulus. A detailed description of this is given in the section on reactions to sound.

F. Lights in cabinet:

1. A white 40-watt light on infant's left. This is used only for lighting up the interior in making adjustments, and so forth. It is not used with infants.

2. A blue 25-watt frosted light in ceiling. The luminosity is just sufficient to enable the experimenter to apply the stimuli. This is the only light in the cabinet when infants are in it.

3. A white 40-watt light on infant's right, for illumination only in making adjustments. Same as No. 1.

G. The humidifier is not shown. It consisted merely of a heavy Turkish roller towel passing over a roller with crank extending through the cabinet. The bottom of the towel loop passes through a shallow curved pan containing water. A few turns of the crank expose the wet surface of the towel to the air which is being heated. The evaporation of the water in the towel increases the humidity of the air. We found very little use for this arrangement as the air in the room itself had a rather constant humidity. Ventilation was secured through the doors and a special ventilator placed into the roof of the cabinet.

EXPERIMENTAL TECHNIQUE

The room which was assigned to these investigations by the hospital authorities was particularly well suited. It was located next to the nursery, so that it was possible for work to proceed with the minimum disturbance to the hospital routine, as well as to the infant. The room was about 9x12 ft. in size, and had one large window, which was covered with a cardboard, neutral grey in color, so as to eliminate outside light. The only light acting on the infant was that within the experimental cabinet and the shaded lights for the recorder and experimenter. Even though this lighting control differed from the normal lighting conditions of the nursery, the change from the variable lighting conditions in the nursery to the uniform lighting of the experimental room did not disturb the infant noticeably.

The room was equipped with a lavatory and the usual hospital furniture, bed, wardrobe dresser, and bedside table. The bedside table and dresser proved convenient for storing supplies, such as the chemicals for the olfactory and gustatory stimuli, absorbent cotton, sterile applicators, and so forth. After every experimental period, the room was ventilated by lowering the transom above the window.

The temperature within the cabinet was always kept between 78° F. and 85° F., the minimum temperature being 78°. A wet-and-dry-bulb hygrometer was placed inside the cabinet, and readings were taken at regular intervals.

At the begining of the research a white frosted bulb of 25 watts was used, but this was found to be disturbing to the infants. We changed to a blue frosted bulb of 25 watts which registered about .035 foot candles when read from a white-light photometer.

The experimental materials were conveniently located, some of them within the cabinet (light, sound, pressure stimuli); others, such as temperature, taste, olfactory, were placed close at hand outside the cabinet. The auditory stimuli used were: a one-stroke electric bell, a snapper, a Chinese wooden bell, a tin can with a wooden hammer for striking it, a tuning fork of 350 cycles mounted on its resonator. The olfactory air-pressure device was placed inside the cabinet, as was also the flashlight with its special arrangement for holding the calibrated colored and white slides. On the right-hand side of the front end of the cabinet were attached two shelves, one above the other. The upper one was used by the experimenter for writing his protocols. On the lower one were placed the following materials: a test-tube rack which was so modified as to hold the five test tubes containing the taste solutions, and also the five olfactory capsules, a glass jar containing the sterile applicators to be used with the taste solutions, the special applicator for plantar stimulation, the colored slides for the flashlight. The temperature regulating device for taste stood next to the sink and within reach of the experimenter. A more detailed description of the stimuli is given in the sections for the particular stimuli used.

In handling the infants, great care must be taken to guard against the possibility of communicating any contagious disease. There is a strict rule against visitors in the nursery. Anyone handling the infants must wear a sterilized gown. This rule holds even for the nurses. The experimenter and recorder were supplied with special gowns which were worn throughout the experimental period. Before handling each infant the experimenter washed his hands in a lysol solution. The care of the experimental room was assigned by the supervising nurse to one of the nurses on the floor. It was her duty to change the lysol solution and towels every morning, and the gowns every two or three days.

Before each experiment either the recorder or the experimenter inquired as to which infants were available. If more infants were available than could be taken during that one period, a note was always left for the next experimenter, indicating which infants had been used. In this way an attempt was made to use every available infant at least once every day. However, at some times during the year, there were from 10 to 15 infants on hand and during these periods it was not possible to make daily records on each infant. At other periods of the year, there was a shortage and it was possible to get two records a day from the same infant.

After finding out what infants could be used, the experimenter and recorder prepared the various experimental materials, filled the pens for the polygraph record, started the heating unit, and on those days on which the experimental period preceded the control period, the experimenter wrote out his program beforehand. After everything was prepared, the experimenter and recorder went into the nursery and carried the infant into the experimental room in its own bassinet. This was placed upon a chair in front of the cabinet. The infant's blanket was then removed and placed upon the stabilimeter; the sheet was placed upon the blanket. The infant was then placed upon the covered stabilimeter platform.

If the infant began to cry and continued to cry, he was immediately returned to the nursery, and another infant was taken. Only full-term infants in good condition were used. The "precaution" cases in which either the mother, or the infant, or both, were under medical observation for communicable diseases, were not used. Infants whose arms were confined in sleeveless gowns because they caused injury to their faces and eyes by scratching, were not used on those days on which the gown was worn.

The experimental session was divided into two periods—the control period and the experimental period. During the control period the door of the cabinet was closed, and the recorder observed the infant through the small window at his end of the cabinet. He recorded on the paper tape the name and sex of the infant, the date, time, hygrometer readings, position of the

infant, whether asleep or awake, and its condition (wet or dry). The following example will serve as a typical illustration:

Smith, Boy
 April 2, 1928
 10:30 A. M.
 80-60
 P2 As. Dr.

This information was noted at the beginning of the record. The numbers 80-60 refer to the temperatures on the hygrometer; 80° F., for the dry bulb; 60° F., for the wet. The humidity for these temperatures is then calculated and recorded. P2 is a symbol for Posture 2, which is "lying on back facing left"; "As." is the symbol for "asleep." The symbol "Dr." means "dry" in the usual nursery sense. After recording this information, the polygraph motor was started. This unreels a paper strip three and one-half inches wide at a uniform rate, and upon this strip the activity pens, a time marker, and a stimulus marker inscribed a permanent ink record. Upon this strip the recorder also noted the symbols of the specific movements of the infants in relation to the time line. This made it possible to describe the specific movement which corresponded to the quantitative measures recorded by the stabilimeter pens.

To insure uniformity in recording, a code for the various movements was prepared. The records of the several recorders were used in drawing up this code, and the following was adopted as including the most commonly observed specific movements. In some experiments the list was extended, and where this was done notation is made in the proper place. Movements not covered by the code were written in.

TABLE I
 SYMBOLS FOR SPECIFIC MOVEMENTS

PRELIMINARY	
Name and Sex	Aw—awake
Date	Dr—dry
Temperature	Da—damp
Time	W—wet
As—asleep	P—posture

POSTURE

- | | |
|-------------------------------|----------------------------------|
| P1—lying on back facing right | P5—lying on stomach facing right |
| P2—lying on back facing left | P6—lying on stomach facing left |
| P3—lying on left side | P7—lying on back facing up |
| P4—lying on right side | |

GENERAL ABBREVIATIONS

- | | |
|-------------------|------------|
| P—posture | E—eyes |
| B—body as a whole | S—sounds |
| F—feet | Fg—fingers |
| H—hands | Hp—hips |
| L—legs | Hd—head |
| T—toes | M—mouth |

SOUNDS

- | | |
|-------------------|------------------------|
| S1—crying | S8—hiccoughing |
| S2—coughing | S9—organic disturbance |
| S3—sneezing | S10—sucking |
| S4—yawning | S11—whimpering |
| S5—regurgitating | S12—sigh |
| S6—vocalizing | S13—audible breathing |
| S7—choking sounds | |

GENERAL BODY MOVEMENTS

- | | |
|--------------------------------|------------------------|
| B1—rolling | B7—shudder |
| B2—squirming | B8—gasp |
| B3—stretching | B9—organic disturbance |
| B4—rapid breathing | B10—back arched |
| B5—continuous general activity | W—wriggling |
| B6—quick jerk of body | R—restless |

HEAD AND FACE

- | | |
|----------------------|-----------------------------------|
| M1—mouth opened | E1—eyes opened |
| M2—mouth closed | E2—eyes closed |
| M3—pursing lips | E3—tightening of lids or blinking |
| M4—smacking lips | E4—fixating |
| M5—licking lips | E5—follow moving light |
| M6—expelled water | Hd1—head rolling |
| Tg—tongue protruded | Hd2—head to right |
| F1—wry face | Hd3—head to left |
| F2—frown or wrinkled | Hd4—head drawn back |
| F3—grimace | |

ARMS-LEGS-HANDS-FEET

- | | |
|-------------|--------------|
| A—arms | Fg—fingers |
| L—legs | Hp—hips |
| Ft—feet | r—right |
| T—toes | l—left |
| H—hands | |
| 1—extension | 8—rubbing |
| 2—flexion | 9—fanning |
| 3—slashing | 10—trembling |
| 4—kicking | 11—jerking |
| 5—to mouth | 12—raised |
| 6—over head | X—crossed |
| 7—over face | V—together |

Example: "Extension of right leg" would be indicated by rL1, "Hands over head" by H6.

Each investigator memorized the symbols for these specific movements until he was letter perfect. During the experiment the infant was observed by two persons, the recorder and the experimenter. The recorder watched both the experimenter and the infant through a window and recorded the symbols of the specific movements on the paper record. The detailed description of the reaction was recorded by the experimenter on a strip of paper like that used on the polygraph. He also recorded many of the special conditions on a separate protocol. In this way there was a constant checking up of one observer by another, and since all the investigators paired off in various combinations, the reporting became uniform for the group. This method was found to be essential. Each investigator tends to observe some movements rather than others and often misses movements that are important for the particular stimulus being used.

During the control period, the door of the cabinet was closed and only the recorder observed the infant. At the end of the control period, the recorder pressed the stimulus key, wrote the symbols, "end of C. P." and indicated again the time, temperatures, and physiological condition of the infant.

When the experimental period began, the door of the cabinet was opened. The recorder indicated on the polygraph record, by pressing a key, the time at which the stimulus was applied, and such specific movements as had been standardized by the symbols. Both the experimenter's and the recorder's records were rolled up together at the end of the experiment.

To correct for space and time errors in presenting the stimuli, the order of rotation indicated in Table II was adopted. The order of presentation is from (a), (b), (c), etc., to (w), for January 26. On January 27, the order was (k), (l), (m), etc., to (w), (a), (b), etc., to (i), (j). In this way all stimuli were presented in all time relations (first, last, middle, etc.).

The social history of the infant's parentage was obtained from the hospital records. This included the race, age, and occupation of both parents. Additional information was also added whenever available. This included such items as the number of other children living, the chronological position of this child in relation

to the other children of the family, and whether legitimate or illegitimate. The charts containing the birth history were also available. Records were kept of the child's birth-weight and length, condition of mother, and so on.

The morning feeding period was at about ten o'clock, and the afternoon feedings at about one o'clock.

Our records include more data than will appear in the tables and conclusions. As yet the number of cases for many of the cate-

TABLE II
TIME AND SPACE ORDER OF STIMULATION AND PLAN OF STIMULUS
AND CONTROL PERIOD ROTATION.

Program of Stimuli	Order of Rotation	C. P.
(a) Light: Blue, Red	Jan. 26 start with (a)	Pp
(b) Temp. 8° C.	Jan. 27 start with (k)	Mp
(c) Valerian (smell): 1, 2, 3	Jan. 28 start with (e)	Pp., Ep
(d) T. F. (tuning fork): 1, 2, 3	Jan. 29 start with (q)	Pp
(e) Temp. 13° C.	Jan. 30 start with (w)	Mp
(f) Acetic (smell): 1, 2, 3	Jan. 31 start with (c)	Pp, Ep
(g) Snapper (sound): 1, 2, 3	Feb. 1 start with (t)	Pp
(h) Temp. 18° C.	Feb. 2 start with (h)	Mp
(i) Cloves (smell): 1, 2, 3	Feb. 3 start with (n)	Pp, Ep
(j) W. B. (sound): 1, 2, 3	Feb. 4 start with (b)	Pp
(k) Temp. 23° C.	Feb. 5 start with (u)	Mp
(l) Light: Green, Yellow	Feb. 6 start with (j)	Pp, Ep
(m) Temp. 33° C.	Feb. 7 start with (r)	Pp
(n) Ammonia (smell): 1, 2, 3	Feb. 8 start with (f)	Mp
(o) Bell (sound): 1, 2, 3	Feb. 9 start with (i)	Pp, Ep
(p) Temp. 43° C.	Feb. 10 start with (o)	Pp
(q) Air (smell): 1, 2, 3	Feb. 11 start with (d)	Mp
(r) Can (sound): 1, 2, 3	Feb. 12 start with (m)	Pp, Ep
(s) Temp. 48° C.	Feb. 13 start with (l)	Pp
(t) H. Nose	Feb. 14 start with (g)	Mp
(u) H. Arms	Feb. 15 start with (s)	Pp, Ep
(v) Temp. 53° C.	Feb. 16 start with (p)	Pp
(w) Light: White	Feb. 17 start with (a)	Mp
	This order was repeated.	

C. P.—Control Period.

Pp—10 minutes control period precedes the experimental period.

Mp—10 minutes control period is placed in the middle.

Pp, Ep—5 minutes at beginning and 5 minutes at the end.

1, 2, 3, indicates the number of stimulations. Where no number is given, one application was made.

This table does not include all the stimuli that were used. It is given merely to indicate the method and the approximate number of stimuli that were given during one test on one infant.

gories is too few to justify an analysis; but, as our records accumulate, it will be possible to make finer analyses.

THE DATA

Each of the tables will indicate the relation between the reactions and stimulating conditions noted, and the age groups.

Below each table under the item "Legend" the symbols and reaction measures used in the Tables are explained.

The heading "condition" is used for the following data:

Age. This varies from a few hours old to about two weeks. In some tables the age is in days; in other tables two-day groupings are given.

Awake (Aw), indicates that the infant's eyes were open.

Asleep (As), indicates that the infant's eyes were closed.

W, D, indicates wet or dry in the nursery sense.

In the tables various combinations of these conditions will appear such as: AsDr, asleep and dry; AwW, awake and wet. The reaction measures and the stimuli will be given under the various table headings or in the legend underneath. Stabilimeter records were not used when it was necessary for the experimenter to touch the infant during stimulation. After each table are given such conclusions as seem justified from the figures.

The original data were collected in the form indicated by the specimen data sheet, Table III.

This table is self-explanatory in the main. The time is indicated in seconds from the preceding notation of the absolute time. Thus the starting time at which the infant was placed on the stabilimeter was 11:19 A. M. This was the beginning of the control period. The infant remained quiet for 36 seconds, then made a movement which shifted, to the extent of one millimeter, the stabilimeter pen which records the head-foot movements. The specific movement, as recorded in the last column, was that of extending and flexing the left leg, and the stretching the whole body. The slight movement of only 1 millimeter of the stabilimeter pen indicates that these movements were made slowly and gently. At 148 seconds after 11:19 A. M. the infant extended and flexed both legs, and the stabilimeter reading is

TABLE III

SPECIMEN DATA SHEET

Name—N

Date: 3-2-28

Age—4 da.

Wt.—7 lbs., 1½ oz.

Fed—10 A. M.

Temp.—84 dry bulb, 64 wet bulb

Control Period—11:19 to 11:29 A. M.

Asleep, dry, lying on back facing left

Time	H-F Pen	R-L Pen	Stimulus	Reaction
			None	
36	1	.....	.....	Left leg extended and flexed; stretching
144	.....	.....	.....	.....
148	3	1	.....	Legs extended and flexed
242	.....	.....	.....	.....
247	1	.....	.....	Squirming
256	.....	.....	.....	.....
260	1	.....	.....	Squirming
422	.....	.....	.....	.....
427	1	.....	.....	Squirming
517	.....	.....	.....	.....
530	6 3	12 8	.....	Jerk of body; vocalizing; rolling
616	.....	.....	.....	.....

Experimental Period—11:29 to 11:45 A. M.

Asleep, dry, lying on right side

Temp.—86 dry bulb, 65 wet bulb

Time	H-F Pen	R-L Pen	Stimulus	Reaction
9	.....	.....	.....	.....
14	Handl.	.....	.....	.....
32	.....	.....	.....	.....
50	8 3	4 5	Cloves (2)	(1) No reaction (2) Left hand to mouth; rolling, squirming
81	.....	.....	.....	.....
103	4 2	3 5	W. B. (3)	(1) Sharp blink, rolling, squirming, vocalizing (2) Blink (3) No reaction
116	.....	.....	.....	.....
121	1 1	1 1	.....	.....
139	.....	.....	.....	.....
152	Handl.	.....	Temp. 23	Mouth open, head rolling, sucking, stretching
157	1	1	.....	.....
179	.....	.....	.....	.....
197	.....	.....	Green light Yellow light	Slight blink Sharp blink
215	.....	.....	.....	.....
220	Handl.	.....	Temp. 33	Slashing of left arm

Time	H-F Pen	R-L Pen	Stimulus	Reaction
247				
269	14 12	39 36	Ammonia (2)	(1) Slight rolling of head (2) Slashing arms, rolling, sneezed twice
292				
314			Bell (3)	(1) Blink (2) Toes flexed (3) Blink
323				
328	1	1		
332				
346	Handl.		Temp. 43	Arms raised, sucking
364				
377			Air (3)	No R. (3)
395				
418	3 2	2 3	Can (3)	(1) Sharp blink, violent jerk of body (2) Blink, jerk of legs (3) Blink
458				
467	Handl.		Temp. 48	No R.
481				
494	Handl.		Holding nose	Back arched, arms slashing, face red, squirming
512				
530	Handl.		Holding arms	Arms remain in position
544				
553	Handl.		Temp. 53	Jerk of body, arms raised
593				
629			White light	Sharp blink
			Blue light	No R.
			Red light	Sharp blink
652				
661	Handl.		Temp. 8	Jerk of body, arms raised, back arched
688				
701			Valerian (3)	No R. (3)
724				
746		1 1	Tuning fork (3)	(1) No R. (2) Rubbing feet (3) No R.
773				
782	Handl.		Temp. 13	Jerk of body, back arching, arms raised, swallowing
809				
823		1 2	Acetic acid (2)	(1) Right arm raised, sucking (2) Right arm raised, sucking
854				
877			Snapper (3)	No R. (3)
890				
895	Handl.		Temp. 18	Jerk, arms raised, back arching
904				

Asleep, dry

Temp.—85 dry bulb, 65 wet bulb

3 plus 1 mm. At 530 seconds the infant gave a jerk of the body, made mouth sounds of some kind (other than crying), and made rolling movements. The stabilimeter reading for this was 6 plus 3 mm. for the head-foot pen; 12 plus 8 mm. for the right-left pen: a total movement of 29 millimeters.¹ The control period ended at 11:29 A. M.

The cabinet door was now opened and the application of the stimuli began. The stimuli used are given under the heading "Stimulus." At 14 seconds there was some handling such as shifting the position of the infant for easier stimulation, rearranging blanket, and so forth. Whenever the notation "Handl." appears, the stabilimeter is locked so that it will not record. In taste stimulation, for instance, the experimenter usually inserts the applicator into the mouth and perhaps touches the chin or cheeks. Any stabilimeter reading under these conditions is useless because it records both the experimenter's and the infant's movements. At 50 seconds after 11:29 (end of control period) the smell stimulus, cloves, was applied twice. For the first stimulus (1) there was no reaction. When no reaction follows stimulation, the experimenter waits to be sure there is no delayed reaction. The actual length of this waiting period can be derived from the original polygraph record. For the second stimulus (2) the left hand was raised to mouth; rolling began which ended in squirming. The total millimeters of activity for the two stimulations with cloves is expressed by the numbers 8, 3, 4, 5, taken from the stabilimeter record. The detailed distribution of these movements can be derived from the original polygraph record. On the original record the time unit is 4.5 seconds, indicated by a mark in the time line and an audible click. The time in seconds shown in Table III has been calculated from the 4.5 sec. marks on the original record. For determining intervals between stimulations, the 4.5-second click is more convenient than a one-second

¹ It is possible from the stabilimeter pen record to derive the direction of the resultant movement. Each pen has a plus and a minus component. Thus if the H-F pen records plus 4 mm. and the R-L pen plus 4 mm., the resultant motion of the infant was 45 degrees from the head-foot axis, toward the head and to the right. A resultant energy component can be worked out on the principle of the parallelogram of forces. Our records are not yet numerous enough for any specific set of conditions to justify such an analysis.

recorder, which requires too much counting on the part of the experimenter.

The experimental period lasted 904 seconds (11:29 to 11:45 A.M.). At the end of the period the infant was asleep and dry; the temperature was 85° F., and the wet-bulb thermometer for calculating humidity was 65° F.

With two operators very detailed records can be taken. In most cases there was also a third investigator who acted as assistant for the recorder and the experimenter. This saves time in many ways: arranging the stimuli, looking after the applicators, guarding against errors, and maintaining aseptic conditions.

THE POLYGRAPH RECORD

(A) The time line is divided into units of ten time intervals (of 4.5 seconds each) throughout the length of the record. Lines are then drawn across the paper strip so that the periods of activity are separated from those of no activity. The stabilimeter record is shown by the two wavy lines. One pen shows the movements in the head-foot direction, the other in the right-left direction. In recording these movements on the data sheets, the excursion of the pen above the median or rest position is designated minus; a movement below the rest position is plus. From both lines a direction resultant may be established, but this was found to be an unnecessary refinement. The sum in millimeters of the excursion of both pens is regarded as the function of the activity.

(B) The lower section illustrates the application of a sound and an order stimulus, and how the time relations between stimulations and reactions can be determined.

The question may arise as to whether the stabilimeter record is a true function of the total activity. As a matter of fact, the pens actually record the oscillation of the center of gravity of the infant. It sometimes happens that the rate and energy of the movements of different segments of the body are so distributed that they cancel each other, and no change in the shift of the center of gravity occurs even though the energy of the movements is high. This indicates that the stabilimeter does *not* record the actual energy expenditure for those components of the movement

Stabilimeter Record

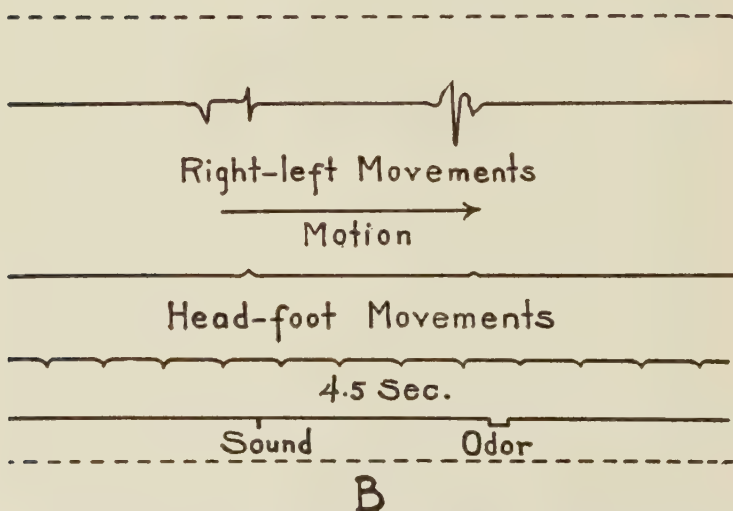
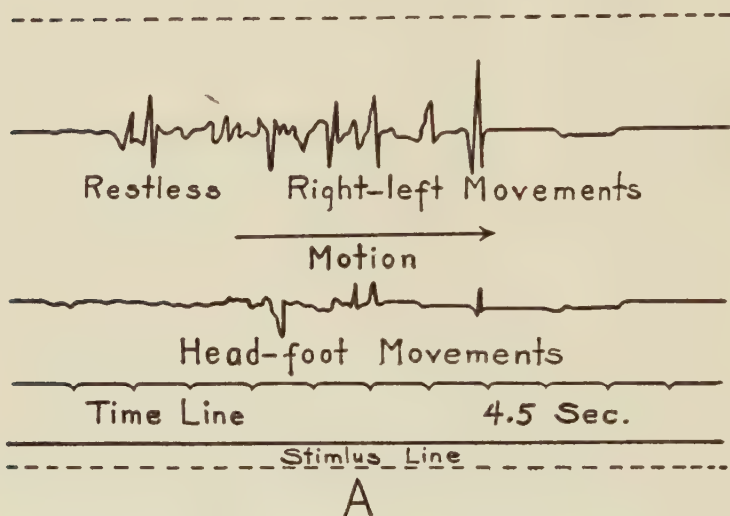


FIG. 3. Reproduction of a section of the stabilimeter polygraph record. The dotted lines represent the edge of the paper strip, three and one-half inches wide.

which cancel each other. Rough calibration of the stabilimeter seems to justify the assumption that *on the whole and covering many records*, our readings do approximate some functional relationship to the actual energy expended by the infant. The calibration indicated that the pen movement was linear for small movements, and became asymptotic for larger movements. This was to be expected from the mechanical spring construction.

The exact functional relationship is a problem in itself and requires an amount of time for its analysis which was regarded as prohibitive since we could not spare the stabilimeter for this length of time. The ideal method would be that of motion studies from motion pictures. However, this is very costly in money and time, and is disturbing to the infant. Some moving pictures were made under low illumination by using a mercury vapor lamp and filtering out the yellow, red, and green. To date, however, we have not been able to secure photographic records under such conditions as would seem to justify the expense of the film, developing, and so forth. We have secured "interesting" records after a considerable amount of "staging" and repetition, but we are not convinced of the scientific usefulness of continuous moving pictures.

THE STABILIMETER MEASUREMENTS

Three methods of investigating the stabilimeter measurements were used in the control period.

(a) Dividing the time in seconds actually active (t), by the total time (T), of the control period and expressing in centiles ($100 t/T$). This gives the percentage of the time during which the infant was actually moving as compared with the total time on the stabilimeter.

(b) Dividing the total activity in millimeters during the entire control period (A) by the weight (W) of the infant in kilograms (A/W). This value gives millimeters of movement per kilogram during the entire control period.

(c) Dividing the total activity (A) in millimeters for the control period, by the weight (W) in kilograms, and then again by the total time in seconds (t) actually active ($A/W/t$). This

value gives millimeters, per kilogram, per second, for the control period.

Other ratios which were used, will be explained under the legend of the particular tables in which they appear. A discussion of these measures will be taken up under the results from the control period. ~

After investigating the various methods of treating the records, percentage or centile values were adopted wherever practical. There are, of course, various objections to this method. It does not indicate the reliability of the data. At present, however, it is out of the question to secure a high degree of statistical reliability in infant behavior. All we expect to do is to present the data in a manner that is easily understood and which admits of verification. The reliability grows as the number of investigations increase. Thus our figures may show that there were 50 per cent reactions to 100 stimulations by the tuning fork. The reliability of this 50 per cent depends on many factors; particularly upon the number of infants. Another investigator using the same technique may secure the value 55 per cent with about the same number of infants. This helps to correct our value in that it can now be regarded as probably too low. The results are easily compared, and for most investigators, they give a fairly uniform picture of the situation. We have given the actual number of cases from which the percentages have been derived, and so it is possible to calculate other central tendencies, for those interested in so doing.

The more complex ratios or reaction measures under (a), (b), (c), were developed in preparation for a more detailed investigation of the individual differences between infants. Even though we reported about 150 specific movements, to group these into categories which give some sort of an inheritance index is a difficult task which has not been attempted. By adding the reaction measures, there is formed another criterion for establishing the individual differences between infants. The next step, as it appears to us, is that of making longer observations. The limit would be 24-hour observations, 7 days a week, for as long as the infant is available. The infant must be fed and looked after,

but the time the infant spends outside of the experimental cabinet can be reduced to some reasonable minimum. Furthermore, not many infants can be handled in this way, as all the observing should be done by the same group of investigators. However, if such a task were performed with even a few infants, much light would be thrown upon the individual differences or inheritance characteristics of infant behavior.

The section headings used, "Reactions to Light," "Reactions to Smell," and so forth, require explanation. To some readers these headings will seem old fashioned as compared with such headings as "Reactions to Olfactory Stimuli," and the like. This is true where only the psychological sensory classifications are used. However, we also investigated the plantar reaction, the sucking reaction, holding the nose, and so on. These belong to medical categories in which much less stress is placed upon the character of the stimulus acting on the receptors. Thus the plantar reaction, from the psychological standpoint, is a reaction to *cutaneous* stimulation. Furthermore even in psychology there is little agreement as to what is to be included under the terms stimulus and reaction. Since these investigations are primarily experimental in character, no attempt was made to enter this systematic controversy. The older classifications were, therefore, adopted because this made it possible to include the physiological reactions with the other forms of stimulation. The observations were restricted primarily to the infant's movements without raising the question as to the nature of the stimulus-reaction relation. The description of the external stimulating conditions makes it possible for others to reproduce them. Such cumbersome phrases as "the stimulus released a reaction," "the stimulus evoked a response," "the stimulus elicited a movement," have also been avoided as much as possible.

CHAPTER II

THE CONTROL PERIOD

As a check for the experimental data, we used a period during which no stimuli were applied. We have named this the "control period." The infant was brought from the nursery in its bassinet and placed upon the stabilimeter. The door of the cabinet was closed, and the infant was observed through the recorder's window. All activities were described and recorded on the polygraph time record. Of course, the infant in the nursery is seldom under such quiescent conditions, but in order to determine the effect of stimulation it was necessary to establish some set of uniform conditions for all infants, at least so far as *external* stimulations were concerned. This control period should not be regarded as representing a "normal" period. There seems to be no such thing in infant behavior.

In the tables which follow two sets of results are presented.

1. The results from a preliminary investigation in which the fifteen-minute control period preceded the application of stimuli.

2. The results from the final investigations in which the control periods were distributed as follows:

(Pp), a 10-minute preperiod before the special stimuli of the experimental period were applied.

(Mp), a 10-minute midperiod at about the middle of the experimental period.

(Pp, Ep), a 5-minute preperiod at the beginning and 5-minute end-period at the end of the experimental period.

The actual distribution of these periods is indicated in Table II.

The two sets of data are differentiated by the terms "Preliminary" and "Final" in the headings of the tables.

The heading "Awake" indicates only that the infant's eyes were open most of the time and "Asleep" that they were closed. That is, our criteria for awake or asleep were eyes open or closed. For infants as young as those in this experiment, the difference between waking activity and sleeping activity is not nearly so great as in later life. We did not use other possible criteria of waking or sleeping, such as respiration rate and pulse rate.

PRELIMINARY INVESTIGATION

TABLE IV
SEX AND RACE DISTRIBUTION
Number of infants—25

	Males	Females	Totals
White	6	4	10
Black	5	10	15
Totals	11	14	25

TABLE V
CONTROL PERIOD 15 MINUTES AT BEGINNING
RELATION BETWEEN:
SEPARATE CONDITIONS; SEPARATE AGE GROUPS
Number of infants—25

Age Days	N	Asleep		Awake		Dry		Wet		Dr. not crying	
		f	%	f	%	f	%	f	%	f	%
0	14	9	64	5	36	13	93	1	7	11	79
1	19	16	84	3	16	17	89	2	11	13	68
2	15	9	60	6	40	14	93	1	7	7	47
3	21	17	81	4	19	17	81	4	19	11	52
4	25	17	68	8	32	23	92	2	8	16	64
5	19	11	58	8	42	12	63	7	37	8	42
6	18	15	83	3	17	12	67	6	33	8	44
7	19	15	79	4	21	17	89	2	11	14	74
8	16	16	100	0	0	9	56	7	44	7	44
9	16	11	69	5	31	11	69	5	31	8	50
10	11	10	91	1	9	4	36	7	64	2	18
11	10	9	90	1	10	5	50	5	50	5	50
12	10	7	70	3	30	6	60	4	40	5	50
13	6	3	50	3	50	3	50	3	50	2	33
14	2	0	0	2	100	1	50	1	50	1	50
15	1	1	100	0	0	1	100	0	0	0	0
16	3	1	33	2	67	2	67	1	33	2	67
17	2	1	50	1	50	2	100	0	0	2	100
T.	227	168		59		169		58		122	
Av. %			74		26		74		26		54

Legend:

Age, age in days. Zero is day of birth.

N, total number of control periods for corresponding age group.

Asleep, eyes closed most of the time.

Awake, eyes open most of the time.

Wet, Dry, terms as used in the nursery sense.

f, number of control periods for the corresponding conditions and age groups.

This value includes cases in which the same infant was given a number of tests and may therefore appear a number of times and under different headings.

%, the f value expressed in centiles (100 f/N).

T, totals of the f values.

Av. %, total of f values expressed as centiles of Total N.

Table V shows that the conditions of the infants were as follows: asleep 74 per cent; awake 26 per cent; dry 74 per cent; wet 26 per cent; not crying 54 per cent. The high per-

centage asleep and dry means only that the experimenter selected those infants that were quiet. Generalizations on the diurnal activity must take this arbitrary weighting into consideration.

TABLE VI
CENTILE OF TIME INFANTS WERE ACTUALLY MOVING
RELATIONS BETWEEN:
REACTION MEASURES; SEPARATE CONDITIONS; SEPARATE AGE GROUPS
CONTROL PERIOD, 15 MINUTES AT BEGINNING
Number of Infants—21
Formula $100\ t/T$

Age	Asleep %	Awake %	Dry %	Wet %	Dry and not crying
0	26	47	34	30	32
1	36	82	35	64	32
2	48	74	56	70	42
3	33	83	38	58	31
4	31	36	22	87	23
5	35	63	42	49	30
6	39	45	37	53	31
7	28	69	35	25	33
8	31	..	25	45	24
9	34	56	33	47	30
10	28	56	27	33	21
11	34	35	25	43	24
12	28	50	42	29	40
13	41	83	68	55	50
14	..	55	50	63	50
15	64	..	64	..	64
16	60	73	77	59	77
17	38	84	50	..	50
Av. % ...	34	60	35	47	31

Legend:

The N value for separate days are not given; the centile values are averages.

t, the time during the control period in which the infant was actually moving.

T, the total time of the control period.

t/T, the time during the control period in which the infant was actually moving (t), divided by the total time of the control period (T), and then expressed in centiles ($100\ t/T$).

Table VI shows:

1. That infants that are asleep, even with no external stimuli present are making movements during 34 per cent of the time.
2. Infants that are awake are moving 60 per cent of the time.
3. Wet infants are more active (47 per cent) than infants who are dry (35 per cent).
4. Infants dry and not crying are least active, 31 per cent.
5. While there seems to be evidence of a tendency for infants to become more active as they grow older, this tendency is not clear-cut until the age level of about 10 days. The ambiguous

results for the older ages, 14 to 17 days, are probably due to the few infants available at these ages.

The tables which follow give the results of the final investigation with various distributions of the control period.

FINAL INVESTIGATION

TABLE VII
SEX AND RACE DISTRIBUTION
Number of Infants—71

	Males	Females	Totals
White	14	24	38
Black	17	16	33
Total	31	40	71

TABLE VIII
CONTROL, 5-MINUTE PREPERIOD, 5-MINUTE END PERIOD
RELATIONS BETWEEN:
SEPARATE CONDITIONS; SEPARATE AGE GROUPS
Number of Infants—71

Age Days	N	Comp.		Asleep		Awake		Dry		Wet	
		f	%	f	%	f	%	f	%	f	%
0	11	11	100	9	82	2	18	10	91	1	9
1	40	30	75	33	82	7	18	34	85	6	15
2	54	40	74	39	72	15	28	39	72	15	28
3	46	34	74	34	74	12	26	33	72	13	28
4	55	37	67	43	78	12	22	34	62	21	38
5	52	43	83	38	73	14	27	22	42	30	58
6	57	44	76	41	72	16	28	29	51	28	49
7	55	45	82	36	65	19	35	23	42	32	58
8	55	40	73	40	73	15	27	26	47	29	53
9	50	44	88	38	76	12	24	23	46	27	54
10	48	41	85	29	60	19	40	15	31	33	69
11	41	33	80	30	73	11	27	26	63	15	37
12	27	22	81	19	70	8	30	15	56	12	44
13	15	12	80	11	73	4	27	5	33	10	67
14	13	11	85	9	69	4	31	8	61	5	39
Total...	619	487		449		170		342		277	
Av. %..			79		72		28		55		45

Legend:

N, total number of control periods that were started.

Comp., the control periods that were completed. Not all control periods were completed. Sometimes it was necessary to return the infant to the nursery on account of a very obvious lack of cooperation with the experimenter.

f %, number and centiles of N for corresponding ages, or conditions.

Av. %, total f and centiles for the various conditions.

Table VIII shows for the control period with 5-minute pre-period and 5-minute end-period:

1. That the number of infants asleep, 72 per cent, is larger than the number awake, 28 per cent. There seems to be a gradual decrease with age in the number asleep, 82 per cent to 69 per cent, and a gradual decrease with age in the number awake, 82 per cent to 69 per cent, and a gradual increase with age in the number awake, 18 per cent to 31 per cent.

2. That the number of infants wet, 45 per cent, is less than the number that are dry, 55 per cent. This is probably a selective factor on the part of the experimenter. He selects those that are not crying, and these are more likely to be dry (Table V). The number of those dry decreases with age, 91 per cent to 61 per cent; of those that were wet increases, 9 per cent to 39 per cent.

3. The average number who completed the control periods was 79 per cent. With the exception of the very early ages (0, 1, 2, 3, days) the number who completed the control periods increased to 85 per cent at 14 days; this, in the face of the fact that the number awake increases from 18 per cent to 31 per cent, and the number wet from 9 per cent to 39 per cent. Ordinarily these conditions make for greater activity, especially crying, which would reduce the chances of completing the control period. It is probable that the warmer and more humid condition in the cabinet prevents rapid drying. This reduces evaporation and weakens the cold stimulation—one source of the crying reaction.

Other control periods used were distributed as follows:

Ten-minute preperiod; 5-minute preperiod plus 5-minute end-period; 10-minute midperiod; 5-minute preperiod; 5-minute end-period. The number of infants for each of these periods is not yet large enough to give reliable results for each period. Separate tables are therefore not given. However, grouping together the results thus far, they show:

1. That 77 per cent of the infants sleep during the control period, and 23 per cent remain awake most of the time. There seems to be a gradual decrease with age in the number asleep, 85 per cent to 69 per cent, and a gradual increase in the number awake, 20 per cent to 31 per cent.

2. That the number of infants wet, 44 per cent, is less than the number that are dry, 56 per cent.

3. The number who completed the control periods was 89 per cent. The number who completed the control periods increases with age, 73 per cent to 88 per cent.

ACTIVITY RECORDS

As previously indicated the activity record is secured from the stabilimeter readings. In the tables which follow, millimeters—where given—refer only to the movements of the stabilimeter pens, and this movement is the *resultant*, not the actual movement of the infant or any of its segments. To permit other types of comparisons we took the *weight* of the infant into consideration. The stabilimeter is the same for all infants, and a light, active infant may actually show less stabilimeter motion than a heavy passive infant. The various formulae used in representing activity are defined in the legend under the table.

TABLE IX
ALL CONTROL PERIODS COMBINED
MILLIMETERS MOVEMENT PER KILOGRAM
RELATION BETWEEN:
REACTION MEASURES; SEPARATE CONDITIONS; SEPARATE AGE GROUPS
Number of Infants—71

Age Days	N	Comp.	Asleep	Awake	Dry	Wet	As. Dr.
0	40.8	40.8	37.7	54.1	43.8	7.6	41.1
1	44.2	36.4	37.1	39.7	31.1	66.8	29.9
2	59.5	54.2	41.4	92.0	37.4	103.7	32.5
3	81.6	66.8	28.7	216.5	43.2	129.0	27.0
4	69.2	33.6	30.7	71.5	25.9	51.7	24.1
5	81.8	65.2	51.7	112.4	44.6	81.5	44.6
6	77.3	58.7	53.2	81.5	60.3	56.5	52.9
7	102.0	82.8	51.0	153.5	63.3	93.2	64.6
8	103.0	81.2	70.6	123.5	53.5	117.5	42.5
9	90.5	81.9	68.0	142.8	78.3	92.2	70.3
10	89.5	85.6	62.5	131.4	76.0	90.7	50.7
11	103.4	95.6	76.4	147.0	71.2	134.0	68.2
12	92.0	63.3	60.1	73.0	64.4	61.8	51.1
13	110.0	89.5	95.7	40.6	97.9	84.0	97.9
14	204.0	211.0	115.7	631.0	116.5	467.0	116.5
Average	85.6	72.0	58.4	132.2	54.3	95.2	47.7

Legend:

Reaction measure: Millimeters movement per kilogram of body weight (A/W), where A is the total activity during the entire control period measured in millimeters excursion of the stabilimeter pens, W is the weight of infant in kilograms. The value of 40.8 is the average millimeters movement per kilogram of all infants on the day of birth, during the control period.

N, reaction measure value for total number of periods started (whether completed or not), for the separate ages.

Comp., reaction measure for only those in which control period was completed.
Av., average of the reaction measure for the corresponding conditions.

Table IX shows:

1. That with increase in age the amount of activity per unit weight increases from 40.8 to 211.0.

2. That the amount of movement between the waking, 132.2, and sleeping conditions, 58.4, is not quite 3 to 1.

3. That there is almost twice as much activity when the infant is wet, 95.2, as when it is dry, 54.3.

4. That the least activity occurs while the infant is asleep and dry, 47.7.

5. From data not given in the tables, it is found that there is greater activity in the afternoon, 76.2, than in the forenoon, 69.3.

TABLE X
ALL CONTROL PERIODS COMBINED
MILLIMETERS MOVEMENT, PER SECOND, PER KILOGRAM
RELATION BETWEEN:
REACTION MEASURES; SEPARATE CONDITIONS; SEPARATE AGE GROUPS
Number of Infants—71

Age Days	N	Comp.	Asleep	Awake	Dry	Wet	As. Dr.
0	.03	.03	.04	.12	.03	.17	.05
1	.01	.01	.01	.09	.01	.09	.02
2	.01	.01	.01	.08	.01	.05	.01
3	.01	.02	.01	.20	.02	.08	.02
4	.01	.01	.01	.11	.01	.04	.01
5	.01	.01	.01	.05	.02	.02	.02
6	.01	.01	.01	.04	.01	.02	.02
7	.01	.01	.01	.04	.03	.02	.04
8	.01	.01	.02	.06	.03	.03	.02
9	.01	.01	.02	.06	.03	.02	.03
10	.01	.01	.02	.04	.04	.02	.04
11	.01	.02	.02	.07	.02	.05	.03
12	.02	.02	.03	.09	.04	.04	.05
13	.06	.06	.06	.05	.10	.08	.10
14	.07	.09	.09	.59	.10	.39	.10
Average	.01	.01	.02	.08	.02	.04	.03

Legend:

Reaction measure: millimeters movement, per second, per kilogram ($A/W/t$), where A is the total activity during entire control period measured in millimeters excursion of the stabilimeter pens, W is the weight of infant in kilograms, and t is the duration in seconds of the activity A.

Thus, the value .03 means that on the day of birth the infants moved the stabilimeter .03 millimeters per second for each kilogram of body weight during the time they were actually moving (*i.e.*, excluding periods of no movement).

N, reaction measure value for total number of periods started, for separate ages.

Comp., reaction measure for only those infants in which the control period was completed.

Av., reaction measures for the corresponding headings.

Table X shows:

1. That the activity on the day of birth is high for all the conditions; asleep .04; awake .12, and so forth.

2. That after the first day the activity becomes less and does not begin to rise until the end of the first week.

3. That the difference in activity between awake, .08, and asleep, .02, is about 4 to 1, as compared with less than 3 to 1 when, as in Table IX, the time (t) actually moving is considered.

4. From data not given in the table, it is found that the activity in the afternoon, .04, is twice that in the forenoon, .02.

In general we found that our forenoon experiments were more satisfactory than the afternoon experiments. It was this general observation which led to the calculation of the reaction measures for forenoon and afternoon.

TABLE XI

ALL CONTROL PERIODS COMBINED
CENTILES OF TIME INFANTS WERE ACTUALLY MOVING
RELATIONS BETWEEN:

REACTIONS MEASURES; SEPARATE CONDITIONS; SEPARATE AGE GROUPS
Number of Infants—71

Age Days	N	Comp.	Asleep	Awake	Dry	Wet	As. Dr.
0	23	23	20	37	24	12	20
1	22	19	18	32	17	31	15
2	27	22	21	27	17	36	14
3	25	18	15	35	14	30	11
4	24	17	16	39	16	20	15
5	27	23	18	41	20	26	19
6	30	27	23	52	27	28	21
7	30	27	20	49	23	30	22
8	32	26	22	43	21	32	18
9	29	26	22	45	25	28	23
10	30	28	23	41	22	33	17
11	34	31	27	47	28	36	25
12	29	24	23	32	22	27	18
13	26	24	24	18	21	25	21
14	38	35	23	86	23	66	23
Average	28	25	21	42	21	30	18

Legend:

Reaction measure: Centiles of time infants were actually moving, ($100 t/T$) where t is the time in seconds during the control period in which the infant was actually moving, T is the total time in seconds, of the control period.

N, reaction measure value for total number of periods started.

Comp., reaction measure for only those infants who completed the control period.

Av., average reaction measure for the various groupings for all ages.

Table XI shows:

1. That infants asleep even with no external stimuli present are moving 21 per cent of the time.
2. Infants awake are moving 42 per cent of the time.
3. There seems to be a tendency toward an increase with age for those awake, 37 per cent to 86 per cent.
4. Wet infants are more active, 30 per cent, than those who are dry, 21 per cent.
5. The most inactive group are those asleep and dry, 18 per cent.

In the experimental data which follow, the results from the asleep and dry group were selected, partly because it was the largest group, and partly because it showed the most uniform conditions with respect to activity.

A comparison of Tables VI and XI, as shown in Table XII, makes it possible to show the relationship between the preliminary and the final investigation. In the preliminary investigation, the duration of the control period was 15 minutes preceding the experimental period. In the final investigation the control period was 10 minutes in length, and in some cases only 5 minutes. On the whole, the technique of handling apparatus, recording results, and handling infants in the final period showed definite improvement over that of the preliminary one.

TABLE XII
COMPARISON OF PRELIMINARY AND FINAL INVESTIGATIONS
TABLES VI AND XI
CENTILES OF TIME INFANTS WERE ACTUALLY MOVING

	N	Asleep	Awake	Dry	Wet
Prelim.	21	34	60	35	47
Final	71	21	42	21	30
Ratio		1.62	1.43	1.66	1.57

Legend:

N, number of infants.

Reaction measure: Centiles of time infants were actually moving (100 t/T).

t, time in seconds infants were actually moving.

T, total time of control period.

Ratio, the relationship between the preliminary and the final investigations.
Thus 1.62 equals 34/21.

Table XII shows:

1. That the results of the preliminary investigation for the classes asleep, awake, dry, wet, are about the same as in the final investigation. The generally lower values in the final investigation are the result of a change in the construction of the stabilimeter.

2. That a control period of 5 minutes occurring variously as a preperiod, midperiod and end-period in the experimental period shows practically the same thing as a fifteen-minute preperiod.

This is experimentally significant because:

(a) The control period represents that condition in which all the reactions of the infants are most uniform from infant to infant.

(b) There is a saving of time for experimentation, which is usually too short at best.

SUMMARY OF CONTROL PERIOD

1. Conditions during control period. Asleep 72 per cent, awake 28 per cent, dry 55 per cent, wet 45 per cent. Infants who completed experimental period 79 per cent (Table VIII).

2. Millimeters movement per kilogram. Increase of activity from birth to 14 days 40.8 to 211.0; average for two-week period 72.0; rate of increase with age not regular from day to day. Averages for asleep, 58.4, awake, 132.2, dry 54.3, wet 95.2, asleep and dry 47.7. In the most stable groups, asleep, dry, increase of activity with age is most pronounced (Table IX).

3. Millimeters movement per second per kilogram. Increase of activity from birth to 14 days .03 to .09; average for two-week period .01; with exception of the first day, rate of increase with age is fairly regular. Average for asleep .02, awake .08, dry .02, wet .04, asleep and dry .03; in the most stable groups, asleep, dry, asleep and dry, the increase of activity with age is most pronounced (Table X).

4. Percentage of time infants were actually moving. Asleep 21 per cent, awake 42 per cent, dry 21 per cent, wet 30 per cent, asleep and dry 18 per cent (Table XI).

The values in the preliminary investigation, (Table VI), asleep 34 per cent, awake 60 per cent, dry 35 per cent, dry and not crying 31 per cent, are higher than the corresponding values of the final investigation (Table XI), but the same relationship is maintained, as is indicated by the ratios in Table XII.

5. A control period of five minutes introduced as a preperiod, midperiod, and end-period is about as effective as a fifteen-minute preperiod preceding the experimental series.

6. Analysis of data not given in tables shows that 71 per cent of the infants that are awake are not crying. Of the infants that are wet 62 per cent are not crying. When an infant is wet the large area of evaporation produces more stimulation and more activity which constantly increases until the baby's eyes open. After a few seconds, intermittent crying begins, to be followed by a period of continuous crying during which every part of the body is in action. There is flexion and extension of arms, legs, and toes; squirming, kicking; rolling of body and head, and rhythmical crying. Record after record substantiates this conclusion as to the rôle which this type of stimulation (probably thermal) plays. The frequency of this condition increases with age but the stimulating value decreases.

7. There is some evidence to show that infants are more restless in the afternoon than in the forenoon. The values are of the order of 45 per cent activity for the morning, 55 per cent activity for the afternoon. These values were not regarded as sufficiently significant to include them as special morning and afternoon categories in the tables. The data are available in the original typewritten dissertations.

8. The state of nutrition also has some relationship to the waking and sleeping states of the child. It was observed that those infants taken very soon after nursing were not only asleep, but also very quiet—so much so that several times not a single stabilimeter movement was made during the control period. As the time for the next feeding approached more of the infants were awake, restless, and “fussy.” Infants under insufficient nourishment were very restless, but when correction for diet was made they slept soundly.

9. If the average of the three reaction measures is used as a standard to estimate the reliability of the measures, the percentage of time infants were actually moving shows a deviation of 2 per cent; the millimeters movement per kilogram shows a deviation of 1 per cent; while the millimeters movement per second per kilogram shows a deviation of 4 per cent. These deviations are so small that all of the measures may be said to show the same thing. The simplest of these measures to calculate is the percentage of time infants were actually moving, and this is perhaps the most practical measure to use. It can be easily secured by simple linear measurements from the polygraph record. Correcting for the weight of the infant as in the measure, millimeters movement per kilogram (deviation 1 per cent), seems to be the best measure; but, as can be seen, its calculation is too complicated to justify its use for the kind of data that is presented.

CHAPTER III

REACTIONS TO LIGHT

HISTORICAL

Kussmaul (1896) found that the pupillary reaction is lively immediately after birth. One child born prematurely at seven months perceived and followed a light, but did not fixate objects until between the third and sixth weeks.

Genzmer (1873) found that all babes are sensitive to light immediately after birth, and reported a lively pupillary light-reflex in a child eight months old. They often turn the head towards a light placed at the side of the head. A sudden bright light causes convergence of the eyes and, if strong, convulsive closing of the lids. Very sensitive babies grow restless and cry in a very bright light.

Kroner (1881) is reported to have found that infants turn the head to the light even when they cannot fixate the eyes or voluntarily move them. A few minutes after birth, light causes closing of the lids, and if asleep, tightening of the eyelids and general unrest. The pupils react promptly. The movements of the eyes are sometimes coördinated, sometimes ataxic.

According to Preyer (1881), infants at birth "perceive" only the difference between light and darkness and do not distinguish colors correctly until three to four years of age. Garbini (1894), as reported by Parsons (1924), holds that children do not distinguish colors until towards the end of the second year, and that red is distinguished and named more correctly at an earlier age than blue (p. 164). With respect to discrimination at a distance, Preyer found that a child one year old distinguished men sawing wood more than a hundred feet away (p. 195).

In regard to the eye muscles of both the lids and the eyeballs, he reports that incoördinated motions do not disappear until three months after birth (p. 36). At birth the different eye muscles are not coördinated, and newly born children, even when awake, keep their eyes shut far more than they keep them open. When the lids are raised, there appears for the most part a strange

asymmetry. One eye remains open, while the other is shut (p. 22). Asymmetrical movements of the upper right and left lids are even present when the eyes are shut. He also observed that the simultaneous turning of both eyes to the right or the left is not completely coördinated. Coördinated movements between muscles of the lids and those governing the eyeballs are not present in newborn infants. In the fifth week Preyer noticed that when the eyeballs were turning downward, the lids were raised; while the former were turning upward, the latter remained in the same position as before.

Preyer divides the development of fixation into four stages. The first stage is merely the staring at the bright object which is in the field of vision. This occurs either immediately or shortly after birth. The second is the turning of the head from one motionless, extended, bright surface in the field of vision to another. This occurs on the eleventh day. The third is the following of an object in motion, characterized by the associated movements of the eyes, while the head is motionless. This occurs on the twenty-third day. The fourth is the directing of the eyes toward an object at about the tenth week (p. 41-47).

According to Preyer, touching the eyelids, lashes, and cornea, as well as a flash of light or a sharp sound, will release a blinking reaction, from which is derived an acquired reflex called winking. Not until the sixtieth day did he succeed in eliciting a winking reaction by using a quick approach of an object. That an approaching object does not elicit the closing of the eyes at first is likewise maintained by Koffka (1925).

According to Baldwin (1895) color preferences "range themselves in an order of attractiveness, i.e., blue, white, red, green, and brown" (p. 53).

According to Cuignet, as reported by Compayre (1896), strabismus lasts until the twentieth day and according to Espinas, the fourteenth day. According to Preyer, by the fiftieth day almost all irregularity has ceased except during sleep. Compayre also makes the statement that every infant is myopic. This indicates that the curvature of the cornea of the infant is greater than that of the adult and has, therefore, more refractive power.

Feldman (1920) also reports that not all investigators agree on this point, and that it is a retinascopically established fact that practically 98 per cent of the newborn infants are hypermetropic on account of the shorter axis of the infant's eye. However, this hypermetropia is rather weak because of the higher refraction of the infant's cornea and lens. Percentages of hypermetropic cases decrease as the infants become older. This even occurs in the infant's first month after birth. Compayre suggests that, because of the restricted movement of the eyeballs and the head, and also because of the sensibility of the retina, which is confined to the central tract, the peripheral parts would not become sensible to light until later, and then only gradually. Even the data on the visual distance which can be discriminated by infants are very fragmentary, and the conclusions derived therefrom are doubtful. Thus, according to Cuignet, an infant $2\frac{1}{2}$ months old would see 7 or 8 meters; according to Espinas the child 2 months old would not see anything further away than 50 cm., and a child 3 months old not further than one meter.

Marsden's (1903) experiments on the color preferences of his son started out on the one hundred and twenty-fourth day and ended on the three hundred and twenty-second day. He found that in 175 presentations the acceptances were: newspaper 139, yellow 127, red 122, blue 121, white 113, green 114, black 114, brown 107 (p. 40).

According to McDougall (1908) "the experiments made indicate that red, green, and blue are appreciated during the sixth month, since they are decidedly preferred to white and still more decidedly to gray, of equal brightness as the colors. The experiments indicate that in the sixth month no one of these three colors is markedly preferred to others, but there was a faint indication that during the fifth month blue is less appreciated than red" (p. 350).

Myers (1908) concludes that "(a) at a very early age (probably long before the sixth month) infants are susceptible to relatively small differences of brightness, (b) that at this age reds and yellows are distinctly preferred to other colors and colorless objects of far greater brightness, and (c) that novelty may

play an important part in determining the infant's choice of color" (p. 358). He also says, "I contend that the growing experience of the infant is comparable to the gradual adjustment of the lens. Little by little, colors begin to be simultaneously differentiated from one another. What was at first a homogeneous light is later seen to consist of differently colored parts" (p. 361).

Canestrini (1913) made 110 individual experiments on newborn infants, and in several cases several experiments were performed on the same infants. The stimuli he used consisted of bright electric light, medium bright electric light, very weak electric light, and *Bengalische* colored flames. By means of fontanelle (brain volume) tracings and respiratory curves he studied the effects of the various light stimuli (p. 39). He says that white light was used as the stimulus in by far the majority of the 110 visual experiments, so that the results with colored lights cannot be considered as conclusive (p. 39).

The duration of stimulation was varied. Sometimes the source of light was a sudden flash, and other times the light lasted several seconds. Both sleeping and waking infants were used.

With the exception of one infant, which was very much fatigued from other stimuli and had fallen into sound sleep, a clearly observable reaction was produced in all visual experiments. With regard to the above-mentioned infant, the electric light was flashed upon its face three times, while it was asleep, and three times no change was produced in either the breathing or the fontanelle curves. So that out of 110 trials, only three (all of the same infant) showed no reaction (p. 40).

As to the effect of the visual stimulation on the fontanelle curves, Canestrini explains that when the infant is asleep or in a quiet waking state and is stimulated with white light (electric), the curves show a clear stepwise rising of the fontanelle curve and a slight change in the breathing. This follows sometimes immediately after stimulation, sometimes after a latent period of one-half to two seconds (see his Fig. 10; p. 33; infant asleep). If the stimulus is repeated, frequently a more decided reaction is produced and the infant becomes restless (his Fig. 11, p. 41, restlessness shown in third trial).

If the stimulation lasted for a fairly long time, even though the infant was asleep, there appeared a lowering of the respiration curve (his Fig. 12, p. 41), and with the last repetition of the stimulation one can observe that the breathing curve also rises and the infant soon wakes up. If the light is especially intense and the subject shows all the external signs of fear, the curves show a rising of both the fontanelle and breathing curves (his Fig. 13, p. 41). This remarkable rising of the breathing curve he explains in terms of a sudden constriction of the abdominal walls, together with sudden intake of the breath, as is the case in adults when they are frightened. Other strong stimulations in other sense fields show similar curves (p. 40).

Canestrini's Figure 14 shows a marked rise in the curves after flashing on an electric light. The excursion is intensified by the movements of the infant. Fig. 15 on page 43 (infant crying) shows an increase in both curves following upon stimulation with a flashlight (p. 40).

In marked contrast to this is his Fig. 16, p. 44. This curve shows no change due to stimulation with light. But on the contrary three seconds after stimulation the curves show a quieting down, and at one time even the breathing curves disappear, and gradually become small and regular. These small regular curves, however, are not breathing curves, but pulsations of the abdominal blood vessels. Canestrini suggests as an explanation that after a period of marked excitement, as the crying in the earlier portion of the curve shows, the infant is exhausted, and the breathing becomes thoracic and superficial, so that the tight abdominal pneumograph does not register light breathing, and therefore the pulsation of the abdominal blood vessels shows up more markedly. That this conjecture is correct can be seen from the fact that 130 waves per minute were counted and they synchronized with the lower curve of fontanelle pulsation (not shown in his figure).

Whether in this case the quieting was the result of stimulation with light, is questionable. Stimulation in other fields has occasionally produced a similar quieting effect (p. 44).

Holding an object not brightly illuminated before the infant's eyes did not produce a change in the curves. In these experi-

ments, care must be taken to avoid a quick movement, since the air current produced may serve as a tactual stimulation (p. 44).

Colored light, as far as it was studied, produced results similar to those with white electric light. Particular reactions to particular colors could not be established (p. 44).

Canestrini's summary of his observations is as follows:

In general, it seems to be true that the stronger the visual stimulation, the stronger the reaction, *other things being equal*.

One secures variable results, depending upon whether the infant is hungry or fed, whether tired or just awakened from refreshing sleep.

Reactions to light stimulation are almost always produced in infants whose eyes are closed, in sleeping infants as well as those who are crying, if the stimulations are intense enough. Unquestionably the thinness of the lids and the partial opening of the lids are advantageous (p. 45).

Regarding the question of the accompanying feeling tone, that is, whether pleasure or displeasure accompany the reactions to visual stimulations, he states that intense and sudden light stimulation produces in the infant the external reaction of displeasure. He also stresses the fact that all pleasant and unpleasant feelings, and those of anticipation, fear and the like—in fact, all subjective experiences of the infant—because of its different nervous system, must differ from those of the adult (p. 45).

As far as it is possible to draw conclusions from the curves, he concludes that the reactions to visual stimulation are unusually marked, whereas to those stimuli which do not affect the infant unpleasantly, no marked deviation in the curves can be observed.

The experiments show that from the day of birth on, light stimulation of a given intensity produces a distinctly observable change in the fontanelle and breathing curves. The breathing curves produced by stimulation with a very intense light were similar to those of an adult when frightened, even though vision as such is underdeveloped (p. 45).

Valentine (1914), as reported by Parsons (1924), finds that there is good evidence of the presence of the sensations of red, yellow, brown, green, and blue at three months old. The order

of preference is as follows: yellow, white and pink, red, brown and black, blue and green, violet; the order of preference is partly determined by the relative powers of the various colors as stimuli to the organism (p. 168-169).

No attempt has been made in recent experiments to determine the approximate visual distance at which infants discriminate objects. Blanton (1917) only incidentally mentions, "Subject S would follow a hand moved slowly 8 or 9 inches from her face without any accompanying movements of the head" (p. 462). "A large percentage of infants fixated on the light at birth" (p. 461). In feeding, she reports, "These babies as a rule had their eyes open at the beginning of nursing. As they began to get enough food, the eyes would close" (p. 462). Watson (1919) states that there is an orientation of the infant's eyes to the source of light a few hours after birth (p. 265).

Feldman (1920) reports that, though adequate light stimuli are absent in the uterus, sensitivity to light is present before the infant has attained its full maturity. This is shown by a premature (7 months) infant, 24 hours old, which turns its head toward light. He finds that in fixating on bright objects, infants show strabismus or squinting, which is either because the visual axes (that is, the lines between the center of the cornea and the corresponding fovea) are not parallel, or the disc occupies a different angular position in relation to the axis of the globe (p. 590). Opinions on the question of fixation vary from one investigator to another. Thus, "the age at which binocular fixation first occurs has been variously given by different authorities. According to Donders, this takes place immediately after birth; according to Kussmaul, the age of its first occurrence is as late as the third to the sixth week" (p. 604). He finds both corneal and conjunctival reflexes present in the large majority of newborn infants. Even stimulation of the cornea by an indifferent fluid-like saline solution releases lid-closing reactions, sucking, and withdrawal movements. Cold water when applied to the cornea at birth causes swallowing reactions (p. 570, 592).

Feldman (1920) and Koffka (1925) report that the consensual pupillary reflex, that is, contraction of both pupils when

the light is directed into one eye only, is present at birth. Preyer (1881) reports that if one eye of the newborn infant is shut while the other is open, the pupil of the latter expands.

The findings of Pfister and Furmann as reported by Feldman (1920) are as follows:

Pfister found that contraction of pupils to light is present at birth. Sensory stimulation, like pinching the skin, does not cause dilatation of pupils during the first month. There is no pupillary contraction during sleep owing to the imperfect myelination of the optic and oculomotor nerves. Furmann also found that sudden illumination causes pupillary contraction in infants. Besides, slight dilatation of the pupils follows contraction after two or three seconds in about 20 per cent of mature infants and in over 60 per cent of premature infants (pp. 587-588). Feldman also reports that visual acuity is greater in infants than in adults because of the clearness and the transparency of the media and because of the greater excitability of the retina, especially the rods (p. 604). His statement is probably based on observations made on older children. How well it can be applied to newborn infants is an open question.

Among all the reports perhaps the Shermans (1925) have been most accurate both in observation and statement. They conclude that "from our results it may be said that the newborn infant is able to fixate upon a white light, but the coördination is gradually perfected until the age of thirty-four hours, when perfect coördination is possible. This does not mean that momentary strabismus does not occur above this age in random movements of the eyes, but that coördination without strabismus is possible in fixating a single light stimulus" (pp. 63-65).

SUMMARY OF PREVIOUS EXPERIMENTS ON THE REACTIONS TO LIGHT

1. The question whether infant vision is myopic or hypermetropic has not been definitely agreed upon by investigators.

2. Immediately or shortly after birth the following reactions are present: contraction and dilatation of the pupils, consensual pupillary reflex, corneal and conjunctival reflexes.

3. The time at which strabismus disappears has been variously given by different authorities.

4. The movements of the eyelids or the eyeballs are not symmetrical at birth.

5. There is not much coördination at birth between the movements of the eyelids and the eyeballs.

6. Fixation has been claimed by some writers to be present at birth, by others to be an acquired reaction, and by still others, like the Shermans, to be present at birth but improving with age.

7. Preyer has divided the development of fixation into four stages. He also distinguishes blinking from winking, in that the former is an inherited while the latter is an acquired reaction.

8. The visual distance to which infants react discriminatively has also been variously, and only incidentally, given by the different investigators.

9. Regarding the observations on the color preference, each experimenter has his own list of the order of reactions to colors, and most of the experimenters have claimed that color preference as such indicates the genesis of the color sense. Myers has contended that all color "experiences" probably begin to develop at the same time, while Valentine states that each color stimulus has its own power as a stimulus to the organism, and that color preference is only partly determined by brightness.

10. Canestrini has found that reaction to light depends upon the physiological conditions (restless, quiet, sleeping, and awake) of the infants and the intensity of the various stimuli. He also found both summation and quieting effects of the light stimuli, accompaniment of "feeling tones," and the absence of particular reactions to particular colors.

This summary is impressive for the variety of reactions that have been reported rather than for the uniformity of the results that have been secured. As one stage in the historical study of human behavior, it represents excellent achievement; but a scientist contemplating the results is forced to conclude that the best working hypothesis is one which assumes that the study of the reactions to light in infants has just begun, and that in the future conditions for observations must be more carefully controlled.

APPARATUS AND METHOD

In the present investigation three series of experiments were included in the reactions to light: a flashlight series, a color-light series, and a tissue-light series. We began with a preliminary series using an ordinary "Eveready" flashlight. However, the flat lens gave a very uneven light field in which some regions were very bright and some rather dark. When we began the final series in which colors were also used, the "Eveready" flashlight was replaced by one made by the Yale Electric Corporation.

The color-light experiments were made with color filters made up into slides which fitted into a brass cap attached to the Yale flashlight.

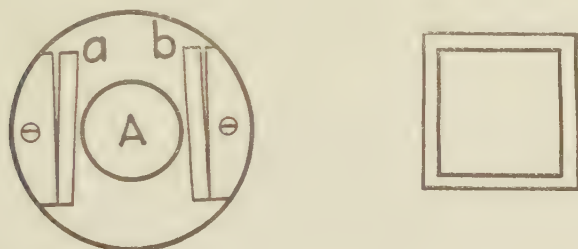


FIG. 4. Slide-holder and slide for flashlight, colored light, and tissue light stimulation.

The round cap shown in Fig. 4 is made of brass, and slips over the flashlight in front of the lens. In the center of the cap is a circular opening (A) 17 mm. in diameter, permitting the light to pass through a slide held between two metal grooves (a) and (b) before the opening.

The square slides are made of two pieces of thin glass on the lantern-slide principle. The slides for the colored lights were made with Wratten color filters with margins firmly bound by black paper tape to prevent their becoming wrinkled or dirty.

The slides used in the color-light experiments were white, yellow, green, red, and blue. For the white stimulus, only two pieces of thin glass were used. This was done in order to keep the intensity of light approximately the same for the white as for the colors. For the color slides Wratten (1927) light filters manu-

factured by the Eastman Kodak Company were used. The constants of these filters are shown in Table XIII.

TABLE XIII

Color	Filter Number	Wave Length	Total Transmission Percentage
Yellow	No. 8	460 Mu & Upward	83.0
Green	No. 61	490 Mu & Upward	18.0
Red	No. 25	590 Mu & Upward	22.0
Blue	No. 46	400 Mu & Upward	2.1

The great variation in luminosity as expressed by the total transmission percentage (from 83.0 per cent for yellow to 2.1 per cent for blue) indicates why results from colored light stimuli are ambiguous. With reflected light one might expect less reliability. In investigating color discrimination in infants, unambiguous results will be secured only when, say, a light red is discriminated from a light green. When a light red is discriminated from a dark green, color discrimination is not established. A study guarding against the brightness-hue equivocation for, say, four colors will require an amount of time which will practically take up the total experimental period during which an infant is available.

In addition to the luminosity as indicated by the transmission percentage, an independent determination of the luminosity of each color slide was made with a Westinghouse foot-candle meter. The determination of the luminosity values for each of the slides is based upon the reports of three adult subjects; these values are given in Table XIV. To secure a white-light stimulus having the same luminosity as the color slides, we used white tissue paper between the glasses. Enough thicknesses of tissue were used to give the same foot-candle readings as the corresponding colored slides. The tissue slide which had the foot-candle value of green was called the W-g tissue slide, and so on. Since the foot-candle value for the yellow slide was nearly the same as for the original white, the latter was used twice in each experimental period, once for white and once for yellow. This only shows that the photometer comparison light is not white but actually yellow, a fact known by all illuminating engineers.

The same flashlight was used for all the color and tissue slides. The battery was replaced every twenty days to insure strength.

To give a light stimulus, the flashlight with the proper slide was held about three inches from the infant's eyes and flashed three times, with a time interval of 4.5 seconds between stimulations.

After January 26, 1928, a system of rotation of the stimuli and a change of the position of the control periods was adopted. The new program and the order of rotation are given in Table II.

For each of the color and tissue slides the number of stimulations was reduced from three to one, and the time interval between

TABLE XIV

Color Slides	Foot-candle Meter Readings	Tissue Light Slides
White	4.50	W-w
Yellow	4.50	W-y
Green	2.00	W-g
Red	1.60	W-r
Blue	.08	W-b

stimulations was lengthened from 4.5 seconds to 9 seconds to allow for the changing of the slides.

If the total transmission percentage of the colored filters as shown in Table XIII is compared with the foot-candle readings in Table XIV, a marked discrepancy appears. Either the transmission is not a function of luminosity, or the reading of colored light from a photometer with an approximately white standard lamp does not give the same readings.

Table XV shows this discrepancy more clearly. In preparing this table, the white light transmission was taken as equal to the yellow transmission (83.0 per cent) in Table XIII. Since we had no actual value for this, we assumed that the clear glass slide which was used with the white flashlight, cut down the transmission to about the same extent as the yellow filter. This is justified partly by the fact that the candle-power of the white light 4.50 (Table XIV) was the same as that for the yellow, also 4.50.

When both transmission and candle-power are expressed as percentage of the totals shown under Tr and c-p, the discrepancy as indicated under Tr% and c-p% is quite marked. Even the order does not remain the same. Red, which shows a transmission proportion of 11 per cent, is higher than that for green, 8 per cent. However, in terms of the c-p proportion, red 13 per cent is lower than green 16 per cent. We made no attempt to work out this

problem but if we compare the results of Table XXXIV, the number of specific movements (Sp.M) and Table XXXV, amount of activity (mm.) with the Tr per cent and c-p per cent, the candle-power readings show the highest correlation with the specific movements.

TABLE XV
RELATION BETWEEN:
TRANSMISSION; CANDLE-POWER; SPECIFIC MOVEMENTS

Colors	Tr	c-p	Sp.M.	mm.	Tr%	Cp%
W	83.0	4.50	26	33	40	35
Y	83.0	4.50	25	48	40	35
G	18.0	2.00	22	13	8	16
R	22.0	1.60	20	6	11	13
B	2.1	.08	7	0	1	1
Total	208.1	12.68	100	100	100	100

Legend:

Tr, percentage transmission of light source as indicated in Table XIII.

c-p., candle-power as read from white light photometer as indicated in Table XIV.

Sp.M., specific movements per stimulation as shown in Table XXXIV.

mm., amount of movement in millimeters of the stabilimeter pens. From Table XXXV.

Tr%, c-p%, transmission and candle-power proportions as derived from Totals of Tr and c-p. $100(83.0/208.1) = 40$

However, the correlation is not at all close. From discussions with other workers who are familiar with the measurement of luminosity of colored lights, we raise the old question as to whether there is a difference between white light luminosity and colored light luminosity. It seems that the structure and function of the adult eye must be regarded as one factor in our definition of luminosity. When we speak of the eye of the infant, the problem becomes more complex still.

We met with the same difficulty in trying to measure the luminosity of a mercury vapor lamp, the light from which was transmitted through filters so as to reduce the transmission of colors other than violet. In this way we reduced the luminosity component without reducing the photographic strength. According to the foot-candle readings, our filters showed very low luminosity. But the readings were obviously much too low when considered in terms of the stimulating value of the filtered violet light. That is to say, the filtered light seemed to be a strong light, even though the foot-candle readings were low.

FLASHLIGHT

TABLES, DATA, AND RESULTS IN PRELIMINARY EXPERIMENTS

In a preliminary series the reactions to visual stimuli were obtained by stimulating the infants' eyes with an ordinary "Eveready" pocket flashlight. This gave irregular illumination and was later replaced by a "Yale" flashlight. The light was flashed three times upon the eyes when they were open, and upon the eyelids if closed. If the infant was awake the light was turned upon the back wall of the apparatus and slowly moved about while the head and eye movements were observed. If the infant was facing the door of the chamber, the door was partially closed and the light spot moved about upon the inner surface.

TABLE XVI
SEX AND RACE DISTRIBUTION
Number of infants—24

	White	Black	Total
Male	5	6	11
Female	9	4	13
Total	14	10	24

TABLE XVII
RELATION BETWEEN:
SEPARATE CONDITIONS; SEPARATE AGE GROUPS
Number of infants—24

Age	S	As. Dr.		As. W.		Aw. Dr.		Aw. W.	
Days	N	f	%	f	%	f	%	f	%
0	3	2	67	1	33	0	0	0	0
1	10	9	90	0	0	1	10	0	0
2	14	9	65	2	14	1	7	2	14
3	10	8	80	1	10	0	0	1	10
4	10	8	80	1	10	1	10	0	0
5	12	5	42	4	33	2	17	1	8
6	16	5	31	8	50	0	0	3	19
7	13	2	15	9	70	2	15	0	0
8	16	3	19	8	50	3	19	2	12
9	19	10	53	6	31	0	0	3	16
10	21	7	33	6	29	2	9	6	29
11	20	7	35	8	40	3	15	2	10
12	9	4	45	4	45	1	10	0	0
13	6	3	50	2	33	0	0	1	17
14	5	5	100	0	0	0	0	0	0
15	2	1	50	0	0	0	0	1	50
Total ..	186	88		60		16		22	
Av. % ..			47		32		9		12
Anal. %			As. 80		Aw. 20		Dr. 56		W. 44

Legend for Table XVII:

S, N, number of tests (three stimulations per test).

As., asleep; Aw., awake; W., wet; Dr., dry. f, %, number and centiles for corresponding ages.

Av.%, T values in centiles.

Anal.%, separate conditions in centiles.

Table XVII shows:

1. That the conditions of the infants were as follows: asleep and dry 47 per cent; asleep and wet 32 per cent; awake and dry 9 per cent; awake and wet 12 per cent.

2. An analysis into the four separate conditions gives: asleep 80 per cent; awake 20 per cent; dry 56 per cent; wet 44 per cent. The high percentage asleep and dry probably shows only that the experimenter is more likely to select a quiet than a restless infant.

3. The significance of the tables showing the distribution of the conditions given is that of indicating what experimental conditions may be found in a well-regulated hospital nursery.

TABLE XVIII

RELATION BETWEEN:

REACTIONS; REACTION MEASURES; WHITE FLASHLIGHT STIMULATION;
ALL CONDITIONS; SEPARATE AGE GROUPS

Number of infants—24

Age	Inf.	S	R		Pac. R.		Sp. M.		Stab. R.		
		n.	N	f	%	f	%	f	av.	amt.	av.
B-1 d	9	45	42	93	0	0	74	1.6	125	2.8	29
2-4 d	15	111	110	99	0	0	136	1.2	212	1.9	19
5-7 d	18	114	110	96	0	0	177	1.5	278	2.4	25
8-10 d	19	99	91	92	3	3	237	2.3	146	1.5	15
11 d	16	124	114	92	3	2	167	1.3	145	1.2	12
Total		493	467		6		791		906	9.8	100
Per cent or Av. ..				95		1		1.6		1.8	

Legend:

Age, birth to 1 day inclusive; 2 to 4 days, etc., 11 days and older. All infants over 11 days are included in this group.

Inf. n., number of infants for the age given.

S, N, number of stimulations.

R, reaction (one reaction may include a number of specific movements); f, %, number and centiles of reactions per stimulation.

Pac. R., pacifying reaction. The cases in which stimulation was followed by a reduction of the general activity to a less active state; f, %, number and centiles of Pac. R. per stimulation.

Sp. M., specific movements as given in Table I; f, av., number and average of Sp. M. per stimulation.

Stab. R., stablimeter record. amt. av., %; total amount, average amount (amt/N), av. in centiles 100 (av/sum of avs.), in millimeters per stimulation.

Preliminary Table XVIII is a composite table of the preliminary data in which only white (slightly yellowish) light was used. It includes the five separate age groups without any attempt at a more complete analysis of the separate conditions. In the tables which follow a more extensive analysis will be made.

Table XVIII shows:

1. That to 493 stimulations there were 95 per cent reactions. Of these 1 per cent were pacifying reactions; there were 1.6 specific movements per stimulation; there were 906 millimeters of measurable activity averaging 1.8 millimeters per stimulation.

2. That the pacifying reactions did not appear until the infants had reached the age of 8 days.

The next series of tables includes the reactions to both white and colored light.

TABLE XIX
COLORED LIGHT
SEX AND RACE DISTRIBUTION

	White	Black	Total
Male	7	8	15
Female	9	8	17
Total	16	16	32

TABLE XX
COLORED LIGHT
RELATION BETWEEN:
SEPARATE CONDITIONS; SEPARATE AGE GROUPS

Age	S	As. Dr.		As. W.		Aw. Dr.		Aw. W.	
Days	N	f	%	f	%	f	%	f	%
0	7	5	71	0	0	2	29	0	0
1	16	14	88	1	6	1	6	0	0
2	19	13	68	2	11	3	16	1	5
3	17	12	70	3	18	0	0	2	12
4	19	12	63	6	32	1	5	0	0
5	19	8	42	5	26	2	11	4	21
6	21	13	62	7	33	0	0	1	5
7	23	10	43	10	43	2	9	1	5
8	15	10	67	4	27	0	0	1	7
9	13	10	77	3	23	0	0	0	0
10	13	6	46	4	31	2	15	1	8
11	10	5	50	4	40	1	10	0	0
12	8	5	63	1	12	2	25	0	0
13	2	2	100	0	0	0	0	0	0
14	2	1	50	0	0	0	0	1	50
Total	204	126		50		16		12	
Av. %			62		24		8		6
Anal. %			As. 86		Aw. 14		Dr. 69		W. 31

Legend for Table XX:

S, N, number of stimulations or tests.

As., asleep; Aw., awake; W., wet; Dr., dry.

f, number of tests for conditions shown; %, centiles of f values.

Anal., analysis of separate conditions in centiles.

Table XX shows:

1. That the conditions of the infants were as follows: 62 per cent asleep and dry; 24 per cent asleep and wet; 8 per cent awake and dry; 6 per cent awake and wet.

2. An analysis of the four separate conditions gives: asleep 86 per cent; awake 14 per cent; dry 69 per cent; wet 31 per cent. The high percentage of asleep and dry merely shows that the experimenter selects the quiet infants rather than the restless ones.

A general analysis of the data is shown in Tables XXI to XXVII, in which all the physiological conditions are combined. A special analysis is made for the "asleep and dry" groups in Tables XXVIII to XXXV, to get the reactions of infants least disturbed by physiological conditions during experimentation.

TABLE XXI
COLORED LIGHT
RELATION BETWEEN:
REACTIONS; REACTION MEASURES; SEPARATE COLORED LIGHT STIMULI;
ALL CONDITIONS; AGE GROUP, BIRTH TO 1 DAY.
Number of infants—14

Stim. C.	S N	R		Pac. R		Sp. M		Stab. R.		
		f	%	f	%	f	av.	amt.	av.	%
W.....	19	19	100	0	0	26	1.4	57	3.0	31
Y.....	17	16	94	0	0	23	1.3	84	4.9	50
G.....	17	14	82	0	0	24	1.4	20	1.2	12
R.....	19	14	74	0	0	20	1.0	14	.7	7
B.....	19	9	47	0	0	12	.6	0	.0	0
Total.....	91	72		0		105		175	9.8	100
Per cent or Average..			79		0		1.1		1.9	

Legend:

Stim C., stimulus color; white (really slightly yellow), yellow, green, red, blue.

S. N., number of stimulations.

R, reactions (one reaction may include a number of specific movements); f, %, number and centiles of reactions per stimulation.

Pac. R., pacifying reactions. The cases in which stimulation was followed by a reduction of the general activity; f, %, number and centiles of pacifying reactions per stimulation.

Sp. M., specific movements as listed in Table I; f. av., number and average (f/N), of specific movements per stimulation.

Stab. R., stablimeter record; Amt., av., %, total amount, average amount (Amt./N), and centiles 100 (av/sum of avs.), of movement of the stablimeter pens, per stimulation.

Table XXI shows:

1. That for the age group birth to 1 day there were 79 per cent reactions; no pacifying reactions; an average of 1.1 specific movements per stimulation; an average of 1.9 millimeters of activity per stimulation.

2. The marked decrease in the percentage of reactions from white to blue is probably only due to the decrease in luminosity from white to blue as shown by Tables XIII and XIV.

TABLE XXII
COLORED LIGHT
RELATION BETWEEN:
REACTIONS; REACTION MEASURES; SEPARATE COLORED LIGHT STIMULI;
ALL CONDITIONS; AGE GROUP, 2 TO 4 DAYS.
Number of infants—27

Stim. C.	S N	R		Pac. R		Sp. M		Stab. R.		
		f	%	f	%	f	av.	amt.	av.	%
W.....	52	52	100	0	0	83	1.6	67	1.3	35
Y.....	50	49	98	0	0	74	1.5	54	1.1	30
G.....	51	45	88	0	0	62	1.2	23	.4	11
R.....	53	43	81	0	0	63	1.2	38	.7	19
B.....	52	18	35	0	0	24	.5	13	.2	5
Total.....	258	207		0		306		195	3.7	100
Per cent or Average..			80		0		1.2		.8	

Legend: Same as for Table XXI.

Table XXII shows that for the age group 2-4 days, there were 80 per cent reactions; no pacifying reactions; an average of 1.2 specific movements per stimulation; an average of .8 mm. of activity per stimulation.

TABLE XXIII
COLORED LIGHT
RELATION BETWEEN:
REACTIONS; REACTION MEASURES; SEPARATE COLORED LIGHT STIMULI;
ALL CONDITIONS; AGE GROUP, 5 TO 7 DAYS.
Number of infants—32

Stim. C.	S N	R		Pac. R		Sp. M		Stab. R.		
		f	%	f	%	f	av.	amt.	av.	%
W.....	51	49	96	0	0	86	1.7	55	1.1	92
Y.....	53	50	94	0	0	65	1.2	8	.1	8
G.....	53	44	83	0	0	67	1.3	3	.0	0
R.....	55	43	78	0	0	64	1.2	4	.0	0
B.....	54	19	35	0	0	20	.4	1	.0	0
Total.....	266	77		0		322		71	1.2	100
Per cent or Average..			77		0		1.2		.2	

Legend: Same as for Table XXI.

Table XXIII shows:

1. That for the age groups 5-7 days there were 77 per cent reactions; no pacifying reactions; an average of 1.2 specific movements, and .2 mm. of activity, per stimulation.

2. The activity for green, red, blue was practically negligible, showing that the brightness (luminosity) of these colors is weak.

TABLE XXIV

COLORED LIGHT

RELATION BETWEEN:

REACTIONS; REACTION MEASURES; SEPARATE COLORED LIGHT STIMULI;

ALL CONDITIONS; AGE GROUP, 8 TO 10 DAYS.

Number of infants—21

Stim. C.	S N	R		Pac. R		Sp. M		Stab. R.		
		f	%	f	%	f	av.	amt.	av.	%
W.....	34	34	100	0	0	54	1.6	26	.8	90
Y.....	38	36	95	0	0	58	1.5	0	.0	0
G.....	38	33	87	1	3	42	1.1	0	.0	0
R.....	36	34	94	0	0	42	1.2	5	.1	10
B.....	34	12	35	0	0	15	.4	0	.0	0
Total.....	180	149		1		211		31	.9	100
Per cent or Average..			83		0		1.2		.2	

Legend: Same as for Table XXI.

Table XXIV shows:

1. That for the age group 8-10 days there were 83 per cent reactions; a negligible percentage of pacifying reactions; an average of 1.2 specific movements per stimulation; an average of .2 mm. of activity per stimulation.

2. Activity for colors yellow, green, red, and blue negligible.

TABLE XXV

COLORED LIGHT

RELATION BETWEEN:

REACTIONS; REACTION MEASURES; SEPARATE COLORED LIGHT STIMULI;

ALL CONDITIONS; AGE GROUP, 11 DAYS AND OLDER.

Number of infants—12

Stim. C.	S N	R		Pac. R		Sp. M		Stab. R.		
		f	%	f	%	f	av.	amt.	av.	%
W.....	18	18	100	0	0	24	1.3	190	10.5	100
Y.....	20	18	90	0	0	28	1.4	0	0	0
G.....	20	18	90	0	0	23	1.1	0	0	0
R.....	17	14	82	0	0	22	1.3	0	0	0
B.....	17	8	47	0	0	11	.6	0	0	0
Total.....	92	76		0		108		190	10.5	100
Per cent or Average..			83		0		1.2		2.1	

Legend: Same as for Table XXI.

Table XXV shows that for the age group 11 days and older there were 83 per cent reactions; no pacifying reactions; an average of 1.2 specific movements per stimulation; an average of 2.1 millimeters of activity per stimulation, and that all the activity was to the white light.

TABLE XXVI
COLORED LIGHT
RELATION BETWEEN:
REACTIONS; REACTION MEASURES; ALL LIGHT STIMULI COMBINED;
ALL CONDITIONS; SEPARATE AGE GROUPS.
Number of infants—32

Age	S N	R		Pac. R		Sp. M		Stab. R.		
		f	%	f	%	f	av.	amt.	av.	%
B-1 d	91	72	79	0	0	105	1.1	175	1.9	37
2-4 d	258	207	80	0	0	306	1.2	195	.7	13
5-7 d	266	205	77	0	0	322	1.2	71	.3	6
8-10 d	180	149	83	1	0	211	1.2	31	.2	4
11 d	92	76	83	0	0	108	1.2	190	2.1	40
Total	887	709	80	1		1052		662	5.2	100
Per cent or Av. .					0		1.2		.8	

Legend:

S. N., number of stimulations for all colors combined.

R, reactions (one reaction may include a number of specific movements); f, %, number and centiles of reactions per stimulation.

Pac. R., pacifying reactions. Cases in which the stimulation was followed by a reduction of the general activity; f, %, number and centiles of pacifying reactions per stimulation.

Sp. M., specific movements as listed in Table I; f, av., number and average (f/N), of specific movements per stimulation.

Stab. R., stabilimeter record; amt., av., %, total amount, average amount (amt./N), and centiles 100 (av/sum of avs.), of movement of the stabilimeter pens, per stimulation.

Table XXVI shows:

1. That there were 80 per cent reactions; that pacifying reactions were negligible; there was an average of 1.2 specific movements per stimulation; and an average of .8 mm. of activity per stimulation.

2. The percentage of activity as indicated by the stabilimeter record is highest for the age level 11 days and older, 40 per cent and lowest for the age level 8-10 days, 4 per cent.

3. While the number of specific movements is lowest at birth 1.1, and remains constant for the other ages 1.2, the millimeters

of activity are high at birth 1.9, drop to .2 at 8-10 days, then jump to 2.1 for 11 days and older. The variation is small, however, as compared with other forms of stimulation and probably indicates that the reactions to light (not necessarily eye coordination) are fairly well established at birth and do not develop as great a degree of specificity during the first two weeks as some of the reactions to other stimuli.

TABLE XXVII
COLORED LIGHT
RELATION BETWEEN:
SPECIFIC MOVEMENTS; SEPARATE COLORED LIGHT STIMULI;
ALL CONDITIONS; SEPARATE AGE GROUPS.
Number of infants—32

Stim. C	B-1 d		2-4 d		5-7 d		8-10 d		11 d		Sum.		
	f	av.	f	av.	f	av.	f	av.	f	av.	f	av.	%
W ...	26	1.4	83	1.6	86	1.7	54	1.6	24	1.3	273	1.5	27
Y ...	23	1.3	74	1.5	65	1.2	58	1.5	28	1.4	248	1.4	24
G ...	24	1.4	62	1.2	67	1.3	42	1.1	23	1.1	218	1.2	21
R ...	20	1.0	63	1.2	64	1.2	42	1.2	22	1.3	211	1.2	20
B	12	.6	24	.5	20	.4	15	1.4	11	.6	82	.7	8
T. f. .	105		306		302		211		108		1032		
av. ..		1.1		1.2		1.2		1.4		1.1		30.0	
%.....		10		30		30		20		10			100

Legend:

Stim. C., stimulus color; white, yellow, green, red, blue.

f, av., number and average of specific movements per stimulation (as listed in Table I).

Sum: specific movements for corresponding colors. f, av., %, total number, average number, and centiles per stimulation.

T. f., av., %, total number, average number, and centiles of specific movements per stimulation for corresponding age groups.

Table XXVII shows:

1. That the number of specific movements to the colored lights was highest for white 27 per cent, then took the order yellow 24 per cent, green 21 per cent, red 20 per cent, blue 8 per cent. This is the same order of percentage transmission as that which resulted from the use of the Wratten filters, shown in Table XIII.

2. That the number of specific movements was highest for the age groups 2-4 days 30 per cent, and 5-7 days 30 per cent. It was lowest for the age groups birth to 1 day 10 per cent, and 11 days and older, also 10 per cent.

TABLE XXVIII
 COLORED LIGHT
 RELATION BETWEEN:
 SPECIFIC MOVEMENT GROUPS; STIMULUS WHITE LIGHT;
 CONDITIONS ASLEEP AND DRY; SEPARATE AGE GROUPS.
 Number of infants—31

Sp. M. Gr.	B-1 d		2-4 d		5-7 d		8-10 d		11 d		Sum.	
	f	%	f	%	f	%	f	%	f	%	f	%
Hd.	10	13	16	8	8	6	7	5	0	0	41	8
Fa.	1	1	0	0	3	2	9	7	0	0	13	2
Bo.	9	12	20	10	1	1	3	2	4	40	37	7
Ext.	5	7	22	11	8	6	17	12	3	30	55	10
So.	1	1	0	0	1	1	0	0	0	0	2	0
Ey.	51	66	139	71	114	84	100	73	3	30	407	73
M.	0	0	0	0	0	0	1	1	0	0	1	0
Su.	0	0	0	0	0	0	0	0	0	0	0	0
T. f.	77		197		135		137		10		556	
Per cent.		14		35		24		25		2		100

Legend:

Sp. M. Gr., specific movement groups. (For a more detailed account see Table I.)

Hd., head movements.

Fa., movements of the facial muscles.

Bo., body movements.

Ext., movements of the extremities.

So., sounds were produced.

Ey., movements of eyes or eye lids.

M., mouth movements (not including sucking).

Su., sucking.

f, %, number and centiles 100 (f/Tf), of specific movements per stimulation for the different age groups.

Sum., f, %, number and centiles of the specific movement groups.

T. f. %, number and centiles of specific movements for separate age groups.

Table XXVIII shows:

1. That color-light reactions were greatest for eye movements 73 per cent.
2. That the head movements decreased with age.
3. That the number of specific movements was greatest for the age group 2-4 days 35 per cent.
4. If the degree of differentiation of the sensorimotor mechanism is measured by the spread of the reaction from the point of stimulation (eyes) to different segments of the body, we find: oculomotor movements (eyes) 73 per cent; movements of the mouth (sucking, sounds, face, head) 10 per cent; bodily reaction (body and extremities) 17 per cent. From these figures, the

reactions to light (if we disregard the finer adjustments of accommodation and convergence) seem to be well developed at birth and during the first two weeks.

In Tables XXIX to XXXV only the conditions asleep and dry are considered. These conditions are the most favorable for determining the effect of a given stimulus.

TABLE XXIX
COLORED LIGHT
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; ALL LIGHT STIMULI;
CONDITIONS ASLEEP AND DRY; SEPARATE AGE GROUPS.
Number of infants—31

Sp. M. Gr.	B-1 d		2-4 d		5-7 d		8-10 d		11 d		Sum.	
	f	%	f	%	f	%	f	%	f	%	f	%
Hd.	5	26	4	7	4	10	0	0	0	0	13	9
Fa.	0	0	0	0	1	3	1	4	0	0	2	1
Bo.	3	16	13	22	0	0	0	0	0	0	16	11
Ext.	1	5	7	12	2	5	5	19	1	50	16	11
So.	0	0	0	0	0	0	0	0	0	0	0	0
Ey.	10	53	35	59	32	82	19	73	1	50	97	67
M.	0	0	0	0	0	0	1	4	0	0	1	1
Su.	0	0	0	0	0	0	0	0	0	0	0	0
T. f.	19		59		39		26		2		145	
Per cent		13		41		27		18		1		100

Legend: Same as Table XXVIII.

Table XXIX shows:

1. That the specific movements to *white light*, 67 per cent were reactions of the eyes; 11 per cent reactions of the body as a whole; 11 per cent reactions of the extremities; 9 per cent reactions of the head; 1 per cent reactions of the face.

2. That the reactions of the eyes were most pronounced for the age group 5-7 days 82 per cent; those of the extremities most pronounced at 11 days and above 50 per cent; of the body as a whole at 2-4 days 22 per cent; of the head at B-1 day 26 per cent; of the face at 8-10 days 4 per cent. This conforms to the general observation that facial expressions become more pronounced with age.

3. That the number of specific movements was greatest at 2-4 days 41 per cent.

TABLE XXX

COLORED LIGHT

RELATION BETWEEN:

SPECIFIC MOVEMENT GROUPS; STIMULUS YELLOW LIGHT;
CONDITIONS ASLEEP AND DRY; SEPARATE AGE GROUPS.

Number of infants—31

Sp. M. Gr.	B-1 d		2-4 d		5-7 d		8-10 d		11 d		Sum.	
	f	%	f	%	f	%	f	%	f	%	f	%
Hd.	3	15	8	6	1	3	5	13	0	0	12	9
Fa.	0	0	0	0	0	0	3	7	0	0	3	2
Bo.	3	15	4	9	0	0	2	5	2	100	11	8
Ext.	2	10	7	15	0	0	3	7	0	0	12	9
So.	0	0	0	0	0	0	0	0	0	0	0	0
Ey.	12	60	33	70	28	97	27	68	0	0	100	72
M.	0	0	0	0	0	0	0	0	0	0	0	0
Su.	0	0	0	0	0	0	0	0	0	0	0	0
T. f.	20		47		29		40		2		138	
Per cent.		14		34		21		29		2		100

Legend: Same as Table XXVIII.

Table XXX shows:

1. That of the specific movements to *yellow light*, 72 per cent were eye movements.

2. The eye movements were most pronounced at 5-7 days 97 per cent; of the extremities at 2-4 days 15 per cent; of the body and head at B-1 days 15 per cent.

3. That the number of specific movements was greatest at 2-4 days 34 per cent.

TABLE XXXI

COLORED LIGHT

RELATION BETWEEN:

SPECIFIC MOVEMENT GROUPS; STIMULUS GREEN LIGHT;
CONDITIONS ASLEEP AND DRY; SEPARATE AGE GROUPS.

Number of infants—31

Sp. M. Gr.	B-1 d		2-4 d		5-7 d		8-10 d		11 d		Sum.	
	f	%	f	%	f	%	f	%	f	%	f	%
Hd.	2	12	3	8	2	6	1	3	0	0	8	7
Fa.	0	0	0	0	1	3	2	6	0	0	3	2
Bo.	2	12	0	0	1	3	1	3	2	100	6	5
Ext.	0	0	2	5	2	6	3	10	0	0	7	5
So.	1	6	0	0	1	3	0	0	0	0	2	2
Ey.	11	69	33	87	26	79	25	78	0	0	95	79
M.	0	0	0	0	0	0	0	0	0	0	0	0
Su.	0	0	0	0	0	0	0	0	0	0	0	0
T. f.	16		38		33		32		2		121	
Per cent.		13		32		27		32		2		100

Legend: Same as Table XXVIII.

Table XXXI shows:

1. That of the specific movements to *green light*, 79 per cent were reactions of the eyes; 7 per cent reactions of the head; 5 per cent reactions of both the extremities and the body as a whole; 2 per cent reactions of the face.

2. That the reactions of the eyes were most pronounced at 2-4 days 87 per cent; those of the head at B-1 day 12 per cent; of the extremities at 8-10 days 10 per cent; of the body at B-1 day 12 per cent; of the face at 8-10 days 6 per cent.

3. That the number of specific movements was greatest at 2-4 days 32 per cent.

TABLE XXXII
COLORED LIGHT
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; STIMULUS RED LIGHT;
CONDITIONS ASLEEP AND DRY; SEPARATE AGE GROUPS.
Number of infants—31

Sp. M. Gr.	B-1 d		2-4 d		5-7 d		8-10 d		11 d		Sum.	
	f	%	f	%	f	%	f	%	f	%	f	%
Hd.	0	0	5	13	1	3	1	4	0	0	7	6
Fa.	1	7	0	0	1	3	3	10	0	0	5	4
Bo.	1	7	3	8	0	0	0	0	0	0	4	4
Ext.	1	7	3	8	2	7	5	17	1	50	12	11
So.	0	0	0	0	0	0	0	0	0	0	0	0
Ey.	11	79	28	72	25	87	20	69	1	50	85	75
M.	0	0	0	0	0	0	0	0	0	0	0	0
Su.	0	0	0	0	0	0	0	0	0	0	0	0
T. f.	14		39		29		29		2		113	
Per cent.		12		34		26		26		2		100

Legend: Same as Table XXVIII.

Table XXXII shows:

1. That of the specific movements to *red light*, 75 per cent were movements of the eyes; 11 per cent movements of the extremities; 6 per cent movements of the head.

2. That the eye movements were most pronounced at 5-7 days 87 per cent; those of the extremities at 11 days and above 50 per cent; of the head at 2-4 days 13 per cent; of the face 8-10 days 10 per cent; of the body as a whole at 2-4 days 8 per cent.

3. The greatest amount of movement occurred at the age level 2-4 days, 34 per cent.

TABLE XXXIII
 COLORED LIGHT
 RELATION BETWEEN:
 SPECIFIC MOVEMENT GROUPS; STIMULUS BLUE LIGHT;
 CONDITIONS ASLEEP AND DRY; SEPARATE AGE GROUPS.
 Number of infants—31

Sp. M. Gr.	B-1 d		2-4 d		5-7 d		8-10 d		11 d		Sum.	
	f	%	f	%	f	%	f	%	f	%	f	%
Hd.	0	0	1	7	0	0	0	0	0	0	1	3
Fa.	0	0	0	0	0	0	0	0	0	0	0	0
Bo.	0	0	0	0	0	0	0	0	0	0	0	0
Ext.	1	12	3	21	2	40	1	10	1	50	8	20
So.	0	0	0	0	0	0	0	0	0	0	0	0
Ey.	7	88	10	72	3	60	9	90	1	50	30	77
M.	0	0	0	0	0	0	0	0	0	0	0	0
Su.	0	0	0	0	0	0	0	0	0	0	0	0
T. f.	8		14		5		10		2		39	
Per cent.		20		86		13		26		5		100

Legend: Same as Table XXVIII.

Table XXXIII shows:

1. That of the specific movements to *blue light*, 77 per cent were eye movements; 20 per cent movements of the extremities; 3 per cent movements of the head.

2. That the eye movements were most pronounced at 8-10 days 90 per cent; those of the extremities at 11 days and above 50 per cent; of the head at 2-4 days 7 per cent. The number of head movements however, is insignificant as compared with those of the extremities and eyes.

TABLE XXXIV
 COLORED LIGHT
 RELATION BETWEEN:
 SPECIFIC MOVEMENTS; SEPARATE LIGHT STIMULI; CONDITIONS
 ASLEEP AND DRY; SEPARATE AGE GROUPS.
 Number of infants—31

Age	W		Y		G		R		B		Sum.	
	f	%	f	%	f	%	f	%	f	%	f	%
B-1 d.	19	25	20	26	16	21	14	18	8	10	77	14
2-4 d.	59	30	47	24	38	19	39	20	14	7	197	35
5-7 d.	39	30	29	21	33	24	29	21	5	4	135	24
8-10 d.	26	19	40	29	32	24	29	21	10	7	137	25
11 d.	2	20	2	20	2	20	2	20	2	20	10	2
T. f.	145		138		121		113		39		566	
Per cent.		26		25		22		20		7		100

Legend for Table XXXIV:

W, Y, G, R, B, are the colored lights white, yellow, green, red, blue.

f, %, total frequencies and centiles of specific movements per stimulation taken from Tables XXIX to XXXIII.

Sum: f, %, total number and centiles of specific movements for age groups given.

T. f. %, total number and centiles of the specific movements per stimulation to the separate colors.

Table XXXIV shows:

1. That for the group asleep and dry the largest proportion of specific movements, 35 per cent were for the age group 2-4 days. That this higher value for this group was maintained for all the light stimuli.
2. That the largest proportion of movements were to the white and yellow lights, 26 per cent and 25 per cent.

TABLE XXXV
COLORED LIGHT
RELATION BETWEEN:
REACTION MEASURES; SEPARATE LIGHT STIMULI; CONDITIONS
ASLEEP AND DRY; SEPARATE AGE GROUPS.
Number of infants—31

Age	W		Y		G		R		B		Sum.	
	amt	%	amt	%	amt	%	amt	%	amt	%	amt	%
B-1 d.	35	31	60	52	14	12	6	5	0	0	115	81
2-4 d.	10	44	9	39	4	17	0	0	0	0	23	16
5-7 d.	1	50	0	0	1	50	0	0	0	0	2	1
8-10 d.	1	33	0	0	0	0	2	67	0	0	3	2
11 d.	0	0	0	0	0	0	0	0	0	0	0	0
Total	47		69		19		8		0		143	
Per cent.		33		48		13		6		0		100

Legend:

W, Y, G, R, B: white, yellow, green, red, blue.

Amt, millimeters of movement per stimulation of the stabilimeter pens for corresponding age group; %, amt. expressed in centiles of the sum.

Sum: amt., %, total activity (millimeters), and centiles for corresponding age group.

Total: total amount and centiles of activity for corresponding colors.

Table XXXV shows:

1. That the amount of movement per stimulation was greatest at B-1 day 81 per cent.
2. That the reactions to white and yellow light were strongest 33 per cent and 48 per cent.

3. For all ages combined, yellow 48 per cent, exceeded white 33 per cent. This is the reverse of Table XXI, which gives 50 per cent for white, and 31 per cent for yellow. Table XXI is for all conditions instead of only asleep and dry. Perhaps yellow light transmitted through closed eyelids, that is, through a filter of red blood corpuscles in the capillaries of the eyelid is not absorbed as readily as white light, thus leaving a larger proportion of the total stimulation to act on the retina.

WHITE-TISSUE SLIDES

In the tables which follow, the stimulating light is actually white light of the same luminosity (as determined from a white-light photometer) as the color slides used in Tables XXI to XXXV.

TABLE XXXVI
SEX AND RACE DISTRIBUTION

	White	Black	Total
Male	3	5	8
Female	5	2	7
Total	8	7	15

TABLE XXXVII
TISSUE LIGHT
RELATION BETWEEN:
SEPARATE CONDITIONS; SEPARATE AGE GROUPS.
Number of infants—15

Age	S	As. Dr.		As. W.		Aw. Dr.		Aw. W.	
Days	N	f	%	f	%	f	%	f	%
0.....	0	0	0	0	0	0	0	0	0
1.....	1	0	0	0	0	0	0	1	100
2.....	3	3	100	0	0	0	0	0	0
3.....	3	0	0	1	33	2	67	0	0
4.....	5	2	40	0	0	2	40	1	20
5.....	5	3	60	2	40	0	0	0	0
6.....	3	0	0	1	33	2	67	0	0
7.....	5	3	60	2	40	0	0	0	0
8.....	6	3	50	2	33	1	17	0	0
9.....	2	0	0	2	100	0	0	0	0
10.....	1	1	100	0	0	0	0	0	0
11.....	2	0	0	0	0	0	0	2	100
12.....	0	0	0	0	0	0	0	0	0
13.....	1	0	0	0	0	0	0	1	100
Total	37	15		10		7		5	
Av. %			41		27		19		13

Anal. % As. 68; Aw. 32; Dr. 60; W. 40.

Legend for Table XXXVII:

S, N, number of stimulations or tests.

As., asleep; Aw., awake; W., wet; Dr., dry.

f, number of cases; % of cases.

Anal., centiles of the separate conditions.

Table XXXVII shows:

1. That the conditions of the infants were as follows: 41 per cent asleep and dry, 27 per cent asleep and wet, 19 per cent awake and dry, 13 per cent awake and wet.

2. An analysis of the four separate conditions gives: asleep 68 per cent; awake 32 per cent; dry 60 per cent; wet 40 per cent.

A general analysis of the data collected in these tests is shown in Tables XXXVIII to XLIV, in which all the conditions are combined.

In Tables XXXVIII to XLII the number of infants is too small to justify conclusions. They have been included only to show how the values in Tables XLIII and XLIV were derived.

As stated on page 71, the white light used in these experiments is of the same luminosity as the colored ones of Tables XXI to XXXV. The symbol W-w indicates that the white-light stimulus was of the same candle power as the white light in the preceding tables; W-y indicates that the stimulus is a white light of the same candle power as the yellow light in the preceding tables, and so forth.

TABLE XXXVIII

TISSUE LIGHT

RELATION BETWEEN:

REACTIONS; REACTION MEASURES; SEPARATE WHITE-TISSUE SLIDES;

ALL CONDITIONS; AGE GROUP BIRTH TO 1 DAY.

Number of infants—1

Stim.	S N	R.		Pac. R.		Sp. M.		Stab. R.		
		f	%	f	%	f	av.	amt.	av.	%
W-w	1	1	100	0	0	1	1.0	0	0	0
W-y	1	1	100	0	0	1	1.0	2	2	100
W-g	1	1	100	0	0	2	2.0	0	0	0
W-r	1	0	0	0	0	0	0	0	0	0
W-b	1	0	0	0	0	0	0	0	0	0
Total	5	3		0		4		2	2	100
Per cent or av..			60		0		1.3		.4	

Legend for Table XXXVIII:

Stim., white-light slides of the same photometric candle power as the colored filter slides used in Tables XXI to XXXV. W-w, white slide of the same c-p as the white light of the colored light series; W-y, white slide of same c-p as yellow filter of the colored light series; etc., etc.

S. N., number of stimulations for the different brightnesses of white light.

R, reactions (one reaction may include a number of specific movements); f, %, number and centiles of reactions per stimulation.

Pac. R., pacifying reactions. The cases in which stimulation was followed by a reduction of the general activity; f, %, number and centiles of pacifying reactions per stimulation.

Sp. M., specific movements as listed in Table I; f, av., number and average (f/N), of specific movements per stimulation.

Stab. R., stabilimeter record; Amt., av., %, total amount, average (Amt./N), and centiles 100 (av./sum of avs.), of movement of the stabilimeter pens per stimulation.

TABLE XXXIX

TISSUE LIGHT

RELATION BETWEEN:

REACTIONS; REACTION MEASURES; SEPARATE WHITE-TISSUE SLIDES;

ALL CONDITIONS; AGE GROUP 2-4 DAYS.

Number of infants—4

Stim.	S N	R.		Pac. R.		Sp. M.		Stab. R.		
		f	%	f	%	f	av.	amt.	av.	%
W-w	9	9	100	0	0	16	1.8	46	5.1	100
W-y	7	6	86	0	0	6	.8	0	0	0
W-g	7	5	70	0	0	10	.7	0	0	0
W-r	9	8	89	0	0	8	.9	0	0	0
W-b	9	0	0	0	0	0	0	0	0	0
Total	41	28		0		40		46	5.1	100
Per cent or av..			68		0		1.0		1.2	

Legend: Same as for Table XXXVIII.

TABLE XL

TISSUE LIGHT

RELATION BETWEEN:

REACTIONS; REACTION MEASURES; SEPARATE WHITE-TISSUE SLIDES;

ALL CONDITIONS; AGE GROUP 5-7 DAYS.

Number of infants—3

Stim.	S N	R.		Pac. R.		Sp. M.		Stab. R.		
		f	%	f	%	f	av.	amt.	av.	%
W-w	11	10	91	1	9	11	1.0	0	0	0
W-y	11	9	82	0	0	12	1.1	0	0	0
W-g	11	9	82	0	0	15	1.4	0	0	0
W-r	11	7	64	1	9	11	1.0	0	0	0
W-b	11	2	18	0	0	1	.1	0	0	0
Total	55	37		2		50		0		0
Per cent or av..			67		4		.9		0	

Legend: Same as for Table XXXVIII.

TABLE XLI*

TISSUE LIGHT

RELATION BETWEEN:

REACTIONS; REACTION MEASURES; SEPARATE WHITE-TISSUE SLIDES;
ALL CONDITIONS; AGE GROUP 8-10 DAYS.

Number of infants—3

Stim.	S N	R.		Pac. R.		Sp. M.		Stab. R.		
		f	%	f	%	f	av.	amt.	av.	%
W-w	7	7	100	0	0	12	1.7	23	3.3	56
W-y	8	7	88	0	0	8	1.0	7	.9	15
W-g	8	8	100	0	0	11	1.4	0	.0	0
W-r	7	7	100	0	0	10	1.4	12	1.7	29
W-b	7	1	14	0	0	1	.1	0	.0	0
Total	37	30		0	0	42		42	5.9	100
Per cent or av..			81		0		1.1		1.6	

TABLE XLII*

TISSUE LIGHT

RELATION BETWEEN:

REACTIONS; REACTION MEASURES; SEPARATE WHITE-TISSUE SLIDES;
ALL CONDITIONS; AGE GROUP 11 DAYS AND OLDER.

Number of infants—4

Stim.	S N	R.		Pac. R.		Sp. M.		Stab. R.		
		f	%	f	%	f	av.	amt.	av.	%
W-w	4	4	100	0	0	4	1.0	0	0	0
W-y	3	3	100	0	0	3	1.0	0	0	0
W-g	3	3	100	0	0	5	1.7	0	0	0
W-r	3	3	100	0	0	4	1.3	0	0	0
W-b	3	2	67	0	0	2	.7	0	0	0
Total	16	15		0	0	18		0	0	0
Per cent or av..			94		0		1.1			

TABLE XLIII

TISSUE LIGHT

RELATION BETWEEN:

REACTIONS; REACTION MEASURES; ALL WHITE-TISSUE SLIDES;
ALL CONDITIONS; SEPARATE AGE GROUPS.

Number of infants—15

Age	S N	R.		Pac. R.		Sp. M.		Stab. R.		
		f	%	f	%	f	av.	amt.	av.	%
B-1 d.	5	3	60	0	0	4	1.3	2	.4	12
2-4 d.	41	28	68	0	0	40	1.0	51	1.1	38
5-7 d.	55	37	67	2	.4	50	.9	0	.0	0
8-10 d.	37	30	81	0	0	42	1.1	59	1.6	50
11 d.	16	15	94	0	0	18	1.1	0	.0	0
Total	154	113		2		154		112	3.1	100
Per cent or av..			74		1		1.0		.7	

* Legend for Tables XLI, XLII, and XLIII: Same as for Table XXXVIII.

Table XLIII shows:

The number of infants (15) is too small for drawing reliable conclusions, but in so far as a trend is indicated it is as follows:

That to 154 stimulations there were 74 per cent reactions; pacifying reactions were negligible; there was an average of 1 specific movement per stimulation; and an average of .7 mm. of activity per stimulation.

TABLE XLIV
TISSUE LIGHT
RELATION BETWEEN:
SPECIFIC MOVEMENTS; SEPARATE WHITE-TISSUE SLIDES;
ALL CONDITIONS; SEPARATE AGE GROUPS.
Number of infants—15

Stim. C.	B-1 d		2-4 d		5-7 d		8-10 d		11 d		Sum.		
	f	av.	f	av.	f	av.	f	av.	f	av.	f	av.	%
W-w	1	1.0	16	1.8	11	1.0	12	1.7	4	1.0	44	1.3	29
W-y	1	1.0	6	.8	12	1.1	8	1.0	3	1.0	30	1.0	19
W-g	2	2.0	10	.7	15	1.4	11	1.4	5	1.7	43	1.4	28
W-r	0	0	8	.9	11	1.0	10	1.4	4	1.3	33	.9	21
W-b	0	0	0	0	1	.1	1	.1	2	.7	4	.2	3
T. f.	4		40		50		42		18		154		
Av.		.8		.8		9		1.1		1.1		4.8	
Per cent . .	17		18		19		23		23				100

Legend:

Stim. C., white-light tissue slides of same photometric value as the colored filter slides Tables XXI to XXXV.

f, av., number and average of specific movements per stimulation.

Sum.: Specific movements for corresponding stimulus; f, av., %, total number, average number, and centiles of specific movements per stimulation.

T. f., av., %, total number av., and av. centiles of specific movements per stimulation for corresponding age groups.

Table XLIV shows:

1. That the number of specific movements was highest for white, then took the order W-g, 28 per cent; W-r, 21 per cent; W-y, 19 per cent; W-b, 3 per cent. This does not correspond to the percentage transmission of the filters in Table XIII nor does it correspond with the order of candle-powers in Table XIV.

2. That the number of specific movements was highest for the age group 8-10 days and 11 days and older, 23 per cent. In Table XXVII with the colored-light stimuli, the number of specific movements per stimulation was highest at 2-4 and 5-7 days, 30 per cent. This seems to indicate that for infants colored-light

luminosity is not the same as white-light luminosity. However, until this relationship has been established for adults it is futile to speculate on infant reactions from our data.

SUMMARY

1. There is no correspondence between the number of reactions, number of specific movements, and amount of stabilimeter activity as indicated by the following facts:

(a) In the white flashlight stimulations (Table XVIII), these three factors rose and fell independently of one another at practically every age level.

(b) In the color-light stimulations (Table XXVI), the infants showed an increase in the number of reactions at all age levels except one, 5-7 days, maintained a rather constant number of specific movements, and exhibited a tendency toward a decrease in the amount of stabilimeter activity. The marked decrease with age of the stabilimeter activity, 81 per cent at birth, zero per cent at 11 days (Table XXXV), indicates that the general bodily reactions to light become fewer while the less massive movements of the eyes, and so forth, do not change for the different ages.

2. The number of reactions shows no increase with age, as indicated by the following facts:

(a) In the color-light stimulations (Table XXVI), the number of reactions was 79 per cent at B-1 day, 80 per cent at 2-4 days, 77 per cent at 5-7 days, and 83 per cent at both 8-10 days, and 11 days and above.

(b) In the white-tissue stimulations the number of reactions per stimulation (Tables XXXVIII to XLII), was 60 per cent at B-1 day, 68 per cent at 2-4 days, 67 per cent at 5-7 days, 81 per cent at 8-10 days, and 94 per cent at 11 days and above.

3. The number of specific movements per stimulation is fairly constant from birth to 11 days, as indicated by:

(a) In the color-light stimulations (Table XXVI), it was 1.1 at B-1 day and 1.2 for each of the other four age groups.

(b) In the tissue light experiments (Table XLIII), the variation from the average 1.0 for all ages was only .3 specific movements at the most. However, the number of infants (15) is not large enough for reliable results.

4. The amount of measurable activity to light is higher at birth than at 11 days and above, as indicated by:

(a) In the white flashlight stimulations (Table XVIII), the measurable activity per stimulation was 29 per cent at B-1 day, and 12 per cent at 11 days and above.

(b) In the color-light stimulations (Table XXVI), it was 37 per cent at B-1 day and 4 per cent at 8-10 days. The sudden increase between 8-10 days and 11 days (4 per cent to 40 per cent), remains unexplained. In the analysis of the more homogeneous group "asleep and dry" (Table XXXV), there is a consistent decrease with age from 81 per cent at B-1 day to zero at 11 days.

5. The number of specific movements to the different color stimuli (Table XXVII), decreased in the following order: white, yellow, green, red, and blue.

(a) Since the transmission percentage of light (Table XIII), and photometer readings for the different colors (Table XIV), also decreased in conformity with the specific movements (Table XXVII), the effect is probably due to the decreasing luminosities of the colors.

(b) The analysis of the group "asleep and dry" (Table XXXIV), showed that the number of specific movements for all the age groups was 26 per cent to white, 25 per cent to yellow, 22 per cent to green, 20 per cent to red, and 7 to blue.

6. There is not much similarity between the color-light and the tissue-light stimulations (Tables XXVI, XLIII; XXVII, XLIV) except the number of reactions, and the number of specific movements *in general* as indicated by:

(a) That a certain color, say green, has a typical stimulating effect of its own, quite different from a light that is "colorless" but of the same luminosity as W-g.

(b) Since the color series and the luminosity series were not given to the same group of infants our results are not conclusive. For further investigation of the problem the two series must be applied to the same infant, in the same experimental period, and with at least a darker and lighter luminosity for each of the colors. We did not work on this specific problem because it arose after we found that our results with the color filters were ambiguous.

7. The number of reactions of the head (Table XXVIII), tend to decrease as the infants become older, as indicated by:

(a) Of the total number of specific movements to color-light stimulations, the reactions of the head constituted 13 per cent at B-1 day; 8 per cent at 2-4 days; 6 per cent at 5-7 days; 5 per cent at 8-10 days; 0 per cent at 11 days and above.

8. That the light stimulations (Tables XXVIII to XXXIV) release not only reactions of the eyes but also movements of many other parts of the body, seems to indicate that the sensory elements at birth are so diffusely connected with many other motor elements that when an infant reacts at all, it reacts segmentally with various degrees of energy for the different segments.

CHAPTER IV

REACTIONS TO SOUND

HISTORICAL

According to Kussmaul (1859) during the first days of life the most disharmonious noises near the ear seem not to disturb the newborn.

According to Genzmer (1873), who used a bell and tested 15 infants, babies hear on the first or at least the second day of life. He wonders if the child learns to hear by hearing in utero the aortic pulse of the mother, uterine and umbilical sounds as well as its own heartbeats.

According to Kroner (1881) numerous tests showed that the newborn react in the first week to loud sounds, but there is great variation in children and in the same child at different times. They react best when wide- or half-awake.

Moldenhauer, as reported by Preyer (1881) used a French toy, *cri-cri*, which gave a loud, brief, disagreeable sound with discordant, high overtones, and found most of the infants, some below 12 hours of age, reacted to sound at the first trial. Different infants reacted differently and the same infants reacted differently at different times. The reactions he observed were quivering of eyelids, wrinkling of forehead, head movements and sometimes movements of the upper body, screaming and awakening from sleep. The repetition of sound stimuli produced a quieting effect or an entire absence of reaction.

Preyer (1881) holds that the temporary deafness of infants at birth is occasioned by either one or all of the following causes: (1) the filling of the middle ear with mucus, (2) the lack of air in the cavity before respiration, and (3) the temporary closing of the external auditory canal (pp. 72-75). The difficulty of determining the first time at which the newborn infant reacts to sound lies in the fact that there is no characteristic movement which would furnish "an unmistakable sign" of the "sensation of sound" (p. 76). In his observations, his son did not hear by means of the tympanum until the fourth day. On the same day his son

stopped crying when he began to blow a whistle close to him. On the eleventh and twelfth days the quieting effect was even brought about by his voice. On the twenty-fifth day his son showed signs of "fright" to sudden loud noises. On the thirtieth day this "fright" became more strongly manifested. In the fifth week there was an increased sensitivity to sound accompanied by the quick turning of the head. In the sixth week the infant "associated the tones he heard with the oval of the face he saw." In the seventh week the fright at a loud sound was still greater than before (pp. 81-83). Orientation of head to sound did not occur until the eleventh week (pp. 84-85).

Compayre (1896) assigns as the principal reason for the infants' temporary deafness after birth the absence of air in the tympanic cavity (p. 137). Another reason is that the ossicles which transmit the vibrations of sound communicated by the tympanic membrane to the fluid contained in the labyrinth are not yet ready to act (pp. 137-38 footnotes).

Miss Shinn (1900) reports that an infant (her niece) scarcely noticed on its twenty-third day the sound of an ordinary bell unless it was struck suddenly and sharply within about six inches of its ear (p. 72). She gives several probable reasons for the temporary lack of sensitivity to sound: the closing of the outer tube of the ear; the presence of fluid in the middle ear; the narrowness of the outer passage; the imperfect nerve connection with the brain (p. 44).

Peterson and Rainey (1910) in observing the reactions of infants by using a metal rattle, low voice calls, and lip sounds, tearing paper, and falling of a hammer head, found that among 48 cases, 23 reacted to sound within the first three hours, 16 within the first two hours, 11 within the first hour, two within 45 minutes after birth, one within 30 minutes after birth, and one within 10 minutes after birth (p. 15). They conclude that the auditory nerve is already prepared to receive impressions of sound some time before the period of normal birth (p. 22).

Canestrini (1913) reports 279 experiments with auditory stimuli such as mouth organ, ringing bell, whistle, and shooting a toy gun. It is obvious, he says, that with such a large number of tests it was possible to test the infants at different times of the day

and under many different conditions (p. 50). He considers first those (fontanelle and respiratory) curves in which the auditory stimulus did not awaken the infant, or if it was awake, modified the curves decidedly. His Figure 40 shows the curve of a sleeping infant indicating a change in the breathing curve as the result of a whistle of two seconds duration. This change of the breathing curve starts at the end of the stimulation and lasts for a while after the whistle has ceased; the individual waves of the breathing curve become lower and flatter. The individual fontanelle pulsations decrease in number during the change of the breathing curve. A similar result is produced in the same infant by dropping an object (Figure 17). Here the breathing curves are even flatter, and the fontanelle pulsations show no change . . . (p. 51).

In Figures 4, 17, and 19 Canestrini shows that auditory stimuli (which are strong enough to produce pulse and breathing changes in a sleeping infant, but too weak to awaken it) always produce a slowing of the respiration and a flattening of the waves (p. 52).

He concludes therefore that the infant even during the first day after birth, reacts to auditory stimuli while asleep (p. 53).

For infants in the waking state, he reports (Figure 23) that the effect of playing a mouth organ for 13 seconds to an infant two days old and three and one-half hours after feeding, was an immediate increase in brain volume and a greater excursion of the breathing curves with increased irregularity, and a slowing of the pulse. In Figure 24 he shows the same effect. He calls attention to the fact that this condition, which is the usual result for adults, is present in the newborn (p. 55). When the auditory stimulus was repeated a second time after a 15-second interval, the reaction was less, even though the second stimulation lasted three times longer. When the stimulus is repeated a third time, the third reaction is less than the second (p. 59).

Canestrini attributes this gradual diminution of the reaction to certain inhibiting forces which can modify the amplitude of the reaction to a remarkable extent, and from this he concludes that we are not dealing with an automaton, in which the reaction always corresponds to the cause (stimulus) but that we are dealing with much more complicated conditions (p. 59).

When he considered the curves obtained while the infant was crying lustily or was very restless and the effect of vocal or musical auditory stimuli, he noticed immediately the quieting influence of these two forms of stimulation. This is common knowledge for mothers and nurses who wish to quiet infants (p. 59).

The following is Canestrini's summary of his experiments: The results of the experiments with auditory stimuli suggested the question regarding pleasant and unpleasant feelings even more than did the visual ones. He states that if this (pleasantness: slow, pulse, shallow breathing; unpleasantness: rapid pulse, rapid breathing, page 62) is true, then we should conclude that unpleasantness usually accompanies the auditory stimulations. In the adult, increase in pulse rate and decrease and irregularity in breathing are usually associated with attention (p. 62).

His results with restless or crying infants point to a pleasant effect of the stimulus (p. 63). The table on page 63 of his book gives positive and negative results for each type of stimulus.

Kinds of Stimuli	No. of Stimulations	No. of Positive Results	No. of Negative Results	Per cent No Reactions
Clapping of hands	17	16	1	6
Mouth organ	34	25	9	26
Ringling of bell	53	48	5	9
Dropping an object	17	16	1	6
Tuning fork	80	18	12	40
Shooting a toy gun	41	36	5	12
Blowing a toy trumpet	13	12	1	8
Whistle of long duration	12	12	0	0
Whistle of short duration	23	19	4	17
Whispering of mother	10	7	3	30
Whispering of strangers	7	4	3	43
Toy bell	10	6	4	40
Miscellaneous noises	12	9	3	25
Total	279	228	51	

The table shows that the percentage of no reactions is largest for tuning fork 40 per cent; mouth organ 26 per cent; and human voice 30 per cent and 43 per cent.

In 80 per cent of the "no reactions" the infants were either sleeping or "angry." All of the 70 infants used reacted to sound (p. 62). Ages of the infants are from 6 hours to 14 days.

Blanton (1917) reports infants' movements of arms and of the entire body to accidental sounds in the laboratory. The other

stimuli she used, like folding paper bag, blowing of Galton whistle, and striking of tuning fork, released positive reactions. An infant 13 days old turned toward the source of sound; another, 29 days old, showed localizing as well as auditory reactions. Diminution of crying and other reactions by sound stimulation was also noticed in some of the subjects (pp. 470-72).

Before birth the infant reacts to various auditory stimuli. But whether infants hear or react to sound immediately after birth is an open question. Feldman (1920) states that, while the senses of sight and smell lack their adequate stimuli inside the uterus, this is not the case with the sense of hearing. The uterine and umbilical souffles, the sound of the maternal aortic pulse, the conducted sounds of the maternal and foetal hearts, the ramplings of the mother's intestinal tract, the sound produced by the foetal movements, and other sounds conducted from outside, such as the rubbing of the mother's clothes against her body, and so on, all furnish adequate stimuli for the foetal ears. On the other hand, there is no doubt that newborn infants are totally deaf to air and bone conduction during the first few hours of post-natal life (pp. 237-38). The same author contends that the cause of lack of sensitivity to sound stimuli at birth is twofold: (1) the absence of air from the tympanic cavity before pulmonary respiration has been well established; (2) the absence of bone conduction, which is a fact but cannot be easily explained (p. 238).

Walton (1921) reports the presence of blinking or crying to sudden, short, and deep sounds. Since there is no transmission of sounds through the cranial bones at birth, the sound waves must be conducted through the air medium. A pitch-pipe, when applied within one centimeter, released head rotation on the anterior-posterior axis and also a lateral nystagmus. He is of the opinion that infant reaction to sound is a kind of defense movement caused by the function of the semicircular canals (pp. 1010-11).

Koffka (1925) after reviewing some of the work of the early investigators, states that according to these authorities "the human voice seems to affect the child very soon after birth; and, indeed, the first differentiated reactions to auditory stimuli seem to be aroused in this way" (p. 121).

Aldrich (1928) reports a case of conditioned reaction to sound in an infant. The experiment was done on an infant which was reported to show no sign of reaction to even quite loud sound. After the strokes of a dinner-bell and firm scratching of the sole of its right foot were applied simultaneously for 12 or 15 times, the sound stimulus alone released crying and drawing of the right leg, and since then, the infant reacted readily to slight sound stimulation (pp. 36-37).

SUMMARY

1. There are adequate sound stimuli within the uterus. There is no agreement whether or not infants react to sound immediately after birth. Some investigators report the presence of reaction to sound within ten minutes after birth; some report the deafness of infants during the first few hours, and sometimes during the first few days after birth.

2. For those investigators who hold that infants are deaf right after birth, the following reasons have been given: (*a*) absence of air in the auditory meatus or the middle ear before pulmonary respiration takes place; (*b*) absence of bone conduction; (*c*) closing of the auditory cavities with mucus; (*d*) imperfect nerve connections with the brain.

3. Among all kinds of stimuli, the infants seem to react more to sound which is sudden, sharp, and loud.

4. There is no agreement as to when the infants begin to orientate their heads toward the source of sound stimulation. Some writers, like Preyer, give the eleventh week, and others, like Blanton, report the presence of localization between the thirteenth and twenty-ninth day.

5. Infant reactions to sound have even been regarded by one investigator as the function of the semicircular canals.

6. While there is no agreement as to whether or not the infants show differential reactions to noises and tones, Koffka thinks that the earliest differential reactions of infants are to the human voice.

7. Canestrini reports that the reactions to sound depend upon the physiological conditions of the infants (asleep or awake) and

the intensity of the stimuli. Where the sound stimuli are applied to sleeping infants, but are not strong enough to wake them up, the reactions show a quieting effect of stimulation. During the waking state, the same stimuli bring about an increase of activity.

8. Successive repetition of stimuli seems to have a quieting or pacifying effect on the infants.

The conflicting conclusions of the investigators are probably due to the following: (*a*) lack of uniform experimental technique; (*b*) lack of similarity of the stimuli used; (*c*) dominance of individual differences of the infants; (*d*) lack of specific reactions to sound.

APPARATUS AND METHOD

The stimuli used in testing the infants' reactions to sound were:

1. Can. An empty one-pound coffee can. On the bottom a circle 14 millimeters in diameter was marked so that the experimenter could strike it at approximately the same spot in each experiment. This can was not a particularly scientific instrument, but it is difficult to find something that is easy to handle and gives a sharp loud sound.

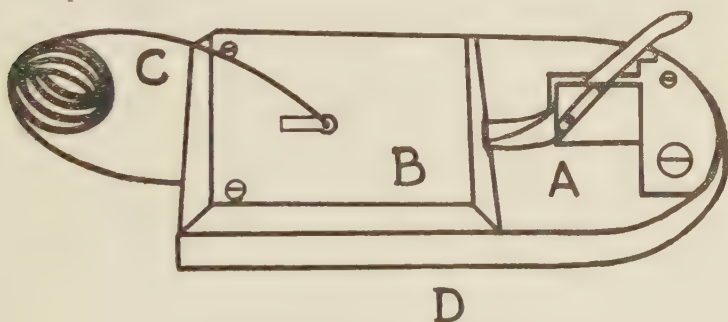


FIG. 5. Snapper for sound stimulation.

2. Snapper. This is shown in Figure 5. It is a mouse-trap arrangement. The small piece of wood *B* snaps on to the base *D* when the raising lever arrangement *A* is depressed. The release is automatic, always occurs at the same point, giving a uniform amplitude. The spring *C* furnishes the pressure for the snaps.

3. Electric bell. This is shown in Figure 6. The sounding bell is an ordinary door bell with a dominant frequency at 600-800 cycles. A key at *n* closes the A.C. circuit. This jerks the armature in the solenoid coil upward so that it strikes the bell a single stroke even though contact is maintained. Both bell and coil are mounted on a small wooden frame and placed about twelve inches back of the infant's head. 

4. A Chinese wooden bell. This is a toy made of light but hard wood, having a small handle at one end and a resonator which divides the bell into two halves at the other. It gives a sharp and shrill sound in the neighborhood of 1500-2000 cycles of very short duration.

5. Tuning fork. This is a good 350-cycle tuning fork mounted on its box-type resonator.

THE RELATIVE LOUDNESS OF THE SOUND STIMULI

Since it was impracticable to determine the composition and amplitude of the complex sound waves produced by the stimuli, the following technique was used to determine the relative loudness of the can, snapper, electric bell, wooden bell, and the tuning fork. The determinations were made on a quiet country road. The experimenter was stationed at a fixed point and operated the stimuli. The subject was in an automobile and instructed to drive one-tenth of a mile, measured by the speedometer of the automobile, then to stop, get out of the machine and turn his back to the experimenter and await the sound stimuli. Each time the subject heard one of the above noises or tones he was to indicate it by raising his arms. The experimenter then presented the sound stimuli in irregular order and made a record of the times the subject did, and did not, respond.

By previous arrangement the subject then drove another tenth of a mile and the procedure was repeated. After each successive series the subject drove a tenth of a mile farther until an approximate limen was obtained for all of the five sound stimuli. The limen here was arbitrarily defined by the distance at which the subject was able to discriminate the stimulus in half of the total number of stimulations. The stimuli were presented in such

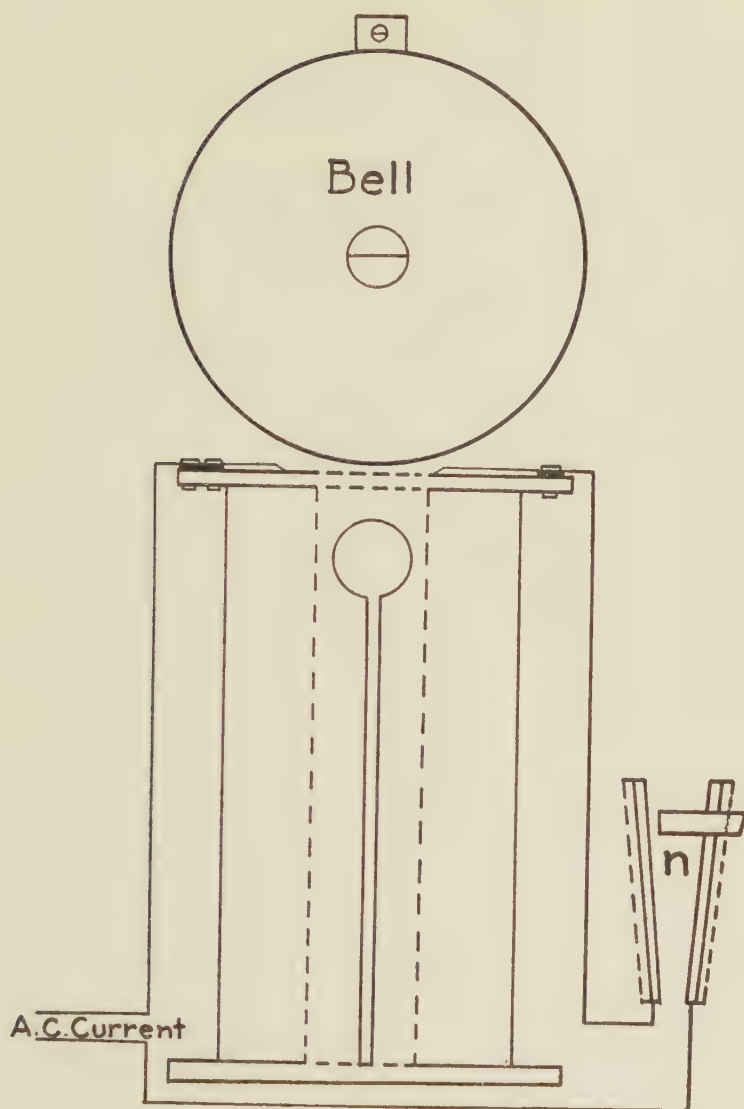


FIG. 6. Electric bell.

irregular order and with such variations in the intervals between presentations that the subject could not anticipate when the next stimulus was expected.

The following table indicates the relative distances at which the stimuli were discriminated in one-half the cases.

TABLE XLV

Stimuli	Distance	
	Miles	Kilometers
Can	.5	.80
Wooden bell	.2	.32
Electric bell	.2	.32
Snapper	.1 to .2	.16 to .32
Tuning fork	.05 to .10	.08 to .16

Two subjects with normal hearing were used. This approximate calibration shows that the can was the loudest of the five sounds, while the tuning fork was the weakest.

The problem of sound calibration is always a difficult one. The loudness of the sound is not only a function of the amplitude of the compound air wave, but depends also upon the distance and any reflecting walls. To determine the reactions to sounds of various intensities with the infants confined within walls (room or cabinet) requires the use of ear tube or head 'phones. This demands a special technique and sound source which is a problem in itself.

From January 26, 1928 on, the rotation system of the control and experimental period was introduced. This is given in Table II.

TABLES, DATA, AND RESULTS

The auditory tests were given to 59 infants, the race and sex distribution of which are shown in Table XLVI.

TABLE XLVI
SEX AND RACE DISTRIBUTION.

	White	Black	Total
Male	13	15	28
Female	19	12	31
Total	32	27	59

TABLE XLVII
SOUND
RELATION BETWEEN:
SEPARATE CONDITIONS; SEPARATE AGE GROUPS.
Number of infants—59

Age	S N	As. Dr.		As. W.		Aw. Dr.		Aw. W.	
		f	%	f	%	f	%	f	%
0.....	11	7	64	1	9	3	27	0	0
1.....	32	26	82	3	9	3	9	0	0
2.....	37	24	65	4	11	6	16	3	8
3.....	33	20	61	7	21	3	9	3	9
4.....	37	26	70	7	19	3	8	1	3
5.....	37	17	46	12	32	1	3	7	19
6.....	42	20	48	17	41	1	2	4	9
7.....	41	13	32	20	49	3	7	5	12
8.....	40	19	48	14	35	4	10	3	7
9.....	37	22	60	11	30	2	5	2	5
10.....	38	14	37	13	34	5	13	6	16
11.....	31	16	52	10	32	4	13	1	3
12.....	22	10	46	6	27	4	18	2	9
13.....	10	4	40	6	60	0	0	0	0
14.....	9	8	89	0	0	0	0	1	11
15.....	3	2	67	0	0	0	0	1	33
21.....	1	1	100	0	0	0	0	0	0
Total	461	249	54	131	28	42	9	39	8
Av. per cent									

Analysis: Per cent As. 82; Aw. 18; Dr. 63; W. 37.

Legend:

S, N, number of stimulations.

As., asleep; Aw., awake; W., wet; Dr., dry.

f, %, number and centiles for corresponding ages.

Av. %, total values in centiles.

Anal. %, separate conditions in centiles.

Table XLVII shows:

1. That the conditions of the infants were as follows: 54 per cent asleep and dry; 28 per cent asleep and wet; 9 per cent awake and dry; 8 per cent awake and wet.

2. An analysis of the separate conditions gives: asleep 82 per cent; awake 18 per cent; dry 63 per cent; wet 37 per cent.

3. The total number of stimulations given to the 59 infants was 461.

The data collected in the auditory experiments are analyzed in Tables XLVIII to LXIII, the first seven of which deal with the infants' reactions to sounds under all physiological conditions, and the last six with only those asleep and dry. The asleep-and-dry group were the most numerous and also the most uniform in their reactions.

TABLE XLVIII

SOUND

RELATION BETWEEN:

REACTIONS; REACTION MEASURES; SEPARATE STIMULI;
ALL CONDITIONS; AGE GROUP BIRTH TO 1 DAY.

Number of infants—27

Stim.	S N	R.		Pac. R.		Sp. M.		Stab. R.		
		f	%	f	%	f	av.	amt.	av.	%
Can	102	61	60	2	2	94	.9	322	3.1	47
Snap.	120	71	59	4	3	103	.8	238	2.0	30
W. B.	109	27	25	0	0	25	.2	7	.1	1
E. B.	102	65	64	6	6	106	1.0	130	1.0	15
T. F.	120	17	14	0	0	20	.2	56	.5	7
Total	553	241		12		408		753	6.7	100
Av. or per cent			44		2		.7		1.4	

Legend:

Stim., kind of stimuli: Can, snapper, wooden bell, electric bell, tuning fork.

S, N, number of stimulations.

R., reactions (one reaction may include a number of specific movements).
f, %, number and centiles of reactions per stimulation.

Pac. R., pacifying reactions. Cases in which stimulation was followed by a reduction of activity. f, %, number and centiles of such reactions per stimulation.

Sp. M., specific movements as shown in Table I. f, av., number and average (f/N) of specific movements per stimulation.

Stab. R., stabilimeter record. Amt., av., %, amount, average, (amt./N), and centiles 100 (av./sum of avs.), of activity per stimulation, in millimeters of movement of the stabilimeter pens.

Table XLVIII shows: That for the age group birth to 1 day, there were 44 per cent reactions, 2 per cent pacifying reactions, an average of .7 specific movements per stimulation, and an average of 1.4 mm. of activity per stimulation.

TABLE XLIX

SOUND

RELATION BETWEEN:

REACTIONS; REACTION MEASURES; SEPARATE STIMULI;
ALL CONDITIONS; AGE GROUP 2-4 DAYS.

Number of infants—48

Stim.	S N	R.		Pac. R.		Sp. M.		Stab. R.		
		f	%	f	%	f	av.	amt.	av.	%
Can	261	196	75	1	1	362	1.4	1117	4.3	56
Snap.	286	145	51	4	1	184	.6	399	1.4	18
W. B.	258	95	37	3	1	141	.7	162	.6	8
E. B.	258	136	53	3	1	248	1.0	327	1.3	17
T. F.	282	44	16	15	5	63	.2	35	.1	1
Total	1345	616		26		998		2040	7.7	100
Av. or per cent			46		2		.7		1.6	

Legend: Same as for Table XLVIII.

Table XLIX shows: That for the age group 2-4 days there were 46 per cent reactions; pacifying reactions 2 per cent; averaging .7 specific movements and 1.6 mm. activity per stimulation.

TABLE L
SOUND
RELATION BETWEEN:
REACTIONS; REACTION MEASURES; SEPARATE STIMULI;
ALL CONDITIONS; AGE GROUP 5-7 DAYS.
Number of infants—49

Stim.	S N	R.		Pac. R.		Sp. M.		Stab. R.		
		f	%	f	%	f	av.	amt.	av.	%
Can	276	185	67	2	1	365	1.3	1117	4.0	46
Snap.	310	147	47	5	2	213	.7	422	1.4	16
W. B.	291	96	33	0	0	130	.4	235	.8	9
E. B.	310	171	55	17	6	260	.8	591	1.9	22
T. F.	306	94	31	6	1	122	.4	172	.6	7
Total	1493	693	46	30	2	1090	.7	2537	8.7	100
Av. or per cent									1.7	

Legend: Same as for Table XLVIII.

Table L shows: That for the age group 5-7 days there were 46 per cent reactions; pacifying reactions 2 per cent; averaging .7 specific movements and 1.7 mm. of activity per stimulation.

TABLE LI
SOUND
RELATION BETWEEN:
REACTIONS; REACTION MEASURES; SEPARATE STIMULI;
ALL CONDITIONS; AGE GROUP 8-10 DAYS.
Number of infants—48

Stim.	S N	R.		Pac. R.		Sp. M.		Stab. R.		
		f	%	f	%	f	av.	amt.	av.	%
Can	279	189	68	6	2	355	1.3	1405	5.0	50
Snap.	293	144	49	6	2	269	.9	503	1.7	17
W. B.	306	124	41	0	0	169	.5	451	1.5	15
E. B.	297	158	53	8	1	265	.9	391	1.3	13
T. F.	318	83	26	10	3	133	.4	151	.5	5
Total	1493	698	47	25	2	1192	.8	2901	10.0	100
Av. or per cent									1.5	

Legend: Same as for Table XLVIII.

Table LI shows: That for the age group 8-10 days there were 47 per cent reactions; pacifying reactions 2 per cent; an average of .8 specific movements per stimulation; an average of 1.5 mm. activity per stimulation.

TABLE LII
SOUND
RELATION BETWEEN:
REACTIONS; REACTION MEASURES; SEPARATE STIMULI;
ALL CONDITIONS; AGE GROUP 11 DAYS AND OLDER.
Number of infants—28

Stim.	S N	R.		Pac. R.		Sp. M.		Stab. R.		
		f	%	f	%	f	av.	amt.	av.	%
Can.	168	108	64	2	1	184	1.1	629	3.7	87
Snap.	201	106	53	0	0	163	.8	553	2.8	28
W. B.	189	61	32	0	0	83	.4	129	.7	6
E. B.	195	106	54	8	4	175	.9	406	2.1	21
T. F.	199	60	30	6	3	81	.4	152	.8	8
Total	952	441		16		686		1874	10.1	100
Av. or per cent			46		2		.7		2.0	

Legend: Same as for Table XLVIII.

Table LII shows: That for the age group 11 days and older there were 46 per cent reactions; pacifying reactions 2 per cent; .7 specific movements and 2 mm. activity per stimulation.

TABLE LIII
SOUND
RELATION BETWEEN:
REACTIONS; REACTION MEASURES; SOUND STIMULI COMBINED;
ALL CONDITIONS; SEPARATE AGE GROUPS.
Number of infants—59

Age	S N	R.		Pac. R.		Sp. M.		Stab. R.		
		f	%	f	%	f	av.	amt.	av.	%
B-1 d.	553	241	44	12	2	408	.7	753	1.4	16
2-4 d.	1345	616	46	26	2	998	.7	2040	1.5	18
5-7 d.	1493	698	46	30	2	1090	.7	2537	1.7	20
8-10 d.	1493	698	47	25	2	1192	.8	2901	1.9	22
11 d.	952	441	46	16	2	686	.7	1874	2.0	24
Total	5836	2689		109		4874		10105	8.5	100
Per cent or av.			46		2		.7		1.7	

Legend:

S, N, number of stimulations.

R, reactions (one reaction may include a number of specific movements).

f, %, number and centiles of reactions per stimulation.

Pac. R., pacifying reactions. The cases in which stimulation was followed by a reduction of general activity. f, %, number and centiles of pacifying reactions per stimulation.

Sp. M., specific movements as shown in Table I. f, av., number and average (f/N) of specific movements per stimulation.

Stab. R., stabilimeter record. Amt., av., %, amount, average, (amt./N), and centiles 100 (av./sum of avs.), of activity per stimulation, in millimeters of movement of the stabilimeter pens.

Table LIII shows:

1. That if the different factors which were included under the infant reactions to sound are considered separately, the following conclusions can be drawn:

(a) The number of times the infant reacted is least for the age group B-1 day, 44 per cent; and most at 8-10 days, 47 per cent. The increase in the number of reactions from the first to the second age group is 2 per cent (44 per cent to 46 per cent). There is no increase from 2-4 days to 5-7 days. From 5-7 days to 8-10 days there is only 1 per cent increase, while between the period 8-10 days and that of 11 days and older there is a decrease of 1 per cent (47 per cent to 46 per cent).

When these percentages are compared with the millimeters movement per kilogram, which increases with age from 40.8 to 211 (Table IX), we would expect a greater increase. That we do not find it may be due to the fact that the nursery life with its many sounds gradually reduces the sensitivity for the sound stimuli under the experimental conditions.

(b) The pacifying reactions being 2 per cent for each age group do not show any appreciable difference from birth to 11 days and older.

(c) The average specific movements per stimulation is highest for the age group 8-10 days. The number is the same for the other four age groups .7.

(d) The amount of activity per stimulation increases as the infants grow older—from 16 per cent at the age level birth-1 day to 24 per cent at 11 days and older. For each age group there is an increase of 2 per cent.

2. That if the different factors are considered collectively, the conclusions hold as follows:

(a) At birth-1 day the infants responded to sound with the lowest reaction-frequency and the least amount of measurable activity, but with the same number of specific movements as at later ages except one, that is, 8-10 days.

(b) From 2-4 days onward, there was very little change in the reaction-frequency and in the number of specific movements, but there was a constant increase of measurable activity, 2 per cent increase for each age group.

TABLE LIV
SOUND
RELATION BETWEEN:
SPECIFIC MOVEMENTS; SEPARATE SOUND STIMULI;
ALL CONDITIONS; SEPARATE AGE GROUPS
Number of infants—59

Stim.	B-1 d		2-4 d		5-7 d		8-10 d		11 d		Sum.	
	f	av.	f	av.	f	av.	f	av.	f	av.	f	%
Can	94	.9	362	1.4	365	1.3	355	1.3	184	1.1	1360	33
Snap.	103	.8	184	.6	213	.7	269	.9	163	.8	932	21
W. B.	25	.2	141	.7	130	.4	169	.5	83	.4	548	12
E. B.	106	1.0	248	1.0	260	.8	266	.9	175	.9	1055	25
T. F.	20	.2	63	.2	122	.4	133	.4	81	.4	419	9
Total...	348		998		1090		1192		686		4313	
Per cent		8		23		25		28		16		100

Legend:

Stim., kind of stimuli; can, snapper, wooden bell, electric bell, tuning fork.

f, av., number and average of specific movements per stimulation.

Sum: f, %, number and centiles of specific movements for corresponding stimulus.

Total, %, total number and centiles of specific movements for corresponding age groups.

Table LIV shows:

1. That 33 per cent of the specific movements were to the sound of the can; 25 per cent to the electric bell; 21 per cent to the snapper; 12 per cent to the wooden bell; 9 per cent to the tuning fork. The low value for the wooden bell 12 per cent, seems to indicate that the reactions to high tones (1500-2000 cycles) are not well established at this early age. This seems to be corroborated in Table LV which gives the frequency of the pacifying reactions.

2. That there is an increase in the number of specific movements from birth to 10 days, 8 per cent to 28 per cent. The sudden increase from 8 per cent to 23 per cent from birth to 4 days seems to support the conclusion that the ear does not function immediately after birth.

TABLE LV
SOUND
RELATION BETWEEN:
PACIFYING REACTIONS; SEPARATE SOUND STIMULI;
ALL CONDITIONS; SEPARATE AGE GROUPS
Number of infants—59

Stim.	B-1 d		2-4 d		5-7 d		8-10 d		11 d		Sum.	
	f	av.	f	av.	f	av.	f	av.	f	av.	f	%
Can	2	15	1	8	2	15	6	47	2	15	13	12
Snap.	4	21	2	21	5	26	6	32	0	0	19	19
W. B.	0	0	3	100	0	0	0	0	0	0	3	3
E. B.	6	16	3	8	17	46	3	8	8	22	37	34
T. F.	0	0	15	41	6	16	10	27	6	16	37	34
Total...	12		26		30		25		16		109	
Per cent		11		24		27		23		15		100

Legend:

Stim, kind of stimuli; can, snapper, wooden bell, electric bell, tuning fork.

f, frequencies as given in Tables XLVIII to LII. %, centiles of f under Sum.

Sum: f, sum of frequencies for different stimuli. %, f in centiles of Total.

Total, f. %, sum of frequencies and centiles for separate age groups.

Table LV shows:

1. That the largest number of pacifying reactions were to the electric bell and tuning fork, 34 per cent each. To the snapper there were 17 per cent; to the can, 12 per cent, and to the wooden bell, 3 per cent.

The low value for the wooden bell 3 per cent, may indicate that reactions to high tones (1500 to 2000 cycles) are faintly observable at those early ages. A low value in this table does not indicate inactivity; it indicates that there was a *change* in activity upon stimulation. This seems to mean that the wooden bell had the highest stimulating value and that the tuning fork and electric bell were the least stimulating.

2. With respect to age, we find the usual quiescent period at the end of the first week (5-7 days). While the 27 per cent at this age is higher than for the other ages, it really indicates a greater tendency toward inactivity because the figures represent pacifying reactions. A low value means *few* pacifying reactions, therefore comparatively high activity. According to our table, the greatest amount of activity or the least number of pacifying reactions occurred at the age level B-1 day.

TABLE LVI
SOUND
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; ALL SOUND STIMULI;
ALL CONDITIONS; SEPARATE AGE GROUPS
Number of infants—59

Sp.M. Gr.	B-1 d		2-4 d		5-7 d		8-10 d		11 d		Sum.	
	f	%	f	%	f	%	f	%	f	%	f	%
Hd.	1	0	3	1	4	1	11	2	12	3	31	1
Fa.	2	1	1	0	8	2	0	0	12	3	23	1
Bo.	75	27	139	22	117	24	183	33	93	25	607	26
Ext.	109	39	254	39	144	30	169	30	138	37	814	35
So.	5	2	15	2	17	4	11	2	13	4	61	3
Ey.	85	31	227	35	185	39	181	33	103	28	781	34
M.	1	0	3	1	0	0	0	0	1	0	5	0
Su.	1	0	2	0	2	0	1	0	1	0	7	0
T. f. ...	279		644		477		556		373		2329	
%		12		29		21		25		13		100

Legend:

Sp. M. Gr., specific movement groups. (For further details see Table I.)

Hd., head movements.

Fa., movements of the facial muscles.

Bo., body movements.

Ext., movements of the extremities.

So., sounds were produced.

Ey., movements of eyes or eyelids.

M., mouth movements (not including sucking).

Su., sucking.

f, %, number and centiles 100 (f/Tf) of specific movements per stimulation for separate age groups.

Sum: f. %, number and centiles of the specific movement groups.

T. f. %, number and average centiles of specific movements for separate age groups.

Table LVI shows:

1. That the reactions to the sound stimuli are: bodily reactions 26 per cent; movements of the extremities 35 per cent; eye movements 34 per cent. The high value for eye movements probably indicates that the sensorimotor mechanism for the visual localization of sound stimuli begins to function even at these early ages.

2. The relatively high value of 29 per cent for age group 2-4 days does not seem to be accidental. It persists through the Tables LVI to LX showing the results from the other forms of stimulation. This seems to support the statement made by some investigators that during the first one or two days the middle ear is filled with fluid and that when this fluid is drained off (between 2-4 days) the reactions to sound are more pronounced.

TABLE LVII
 SOUND
 RELATION BETWEEN:
 SPECIFIC MOVEMENT GROUPS; STIMULUS, CAN; CONDITION ASLEEP
 AND DRY; SEPARATE AGE GROUPS
 Number of infants—55

Sp.M. Gr.	B-1 d		2-4 d		5-7 d		8-10 d		11 d		Sum.	
	f	%	f	%	f	%	f	%	f	%	f	%
Hd.	0	0	1	1	2	1	1	1	7	7	11	1
Fa.	0	0	0	0	4	3	0	0	3	3	7	1
Bo.	21	30	60	25	33	24	80	48	25	24	219	30
Ext.	30	43	111	46	56	40	47	27	43	41	287	41
So.	1	1	8	3	0	0	0	0	5	5	14	2
Ey.	18	26	56	23	44	32	40	24	21	20	179	25
M.	0	0	1	1	0	0	0	0	0	0	1	0
Su.	0	0	2	1	0	0	0	0	0	0	2	0
T. f. ...	70		239		139		168		104		720	
%		10		33		20		23		14		100

Legend: Same as for Table LVI.

Table LVII shows:

1. That of the reactions to the can stimulus, movement of the body 30 per cent, extremities 41 per cent, and eyes 25 per cent, are more numerous than all other forms of movements.

2. That the period 2-4 days, 33 per cent reactions, is significant for the initiation of reactions to sound.

TABLE LVIII
 SOUND
 RELATION BETWEEN:
 SPECIFIC MOVEMENT GROUPS; STIMULUS, SNAPPER;
 CONDITIONS ASLEEP AND DRY; SEPARATE AGE GROUPS
 Number of infants—57

Sp.M. Gr.	B-1 d		2-4 d		5-7 d		8-10 d		11 d		Sum.	
	f	%	f	%	f	%	f	%	f	%	f	%
Hd.	1	1	0	0	2	2	1	1	1	1	5	1
Fa.	1	1	0	0	2	2	0	0	0	0	3	1
Bo.	22	25	12	10	21	19	22	19	17	20	94	18
Ext.	32	37	44	36	20	18	38	32	30	35	164	31
So.	2	3	4	3	1	1	3	2	0	0	10	2
Ey.	28	32	63	51	63	58	54	46	37	45	245	47
M.	1	1	1	1	0	0	0	0	0	0	2	0
Su.	0	0	0	0	0	0	0	0	0	0	0	0
T. f. ...	87		124		109		118		85		523	
%		17		24		21		22		16		100

Legend: Same as for Table LVI.

Table LVIII shows:

1. That to the snapper stimulus, movements of the body 18 per cent; extremities 31 per cent, and eyes 47 per cent, are more numerous than all other forms of movement.

2. That the period 2-4 days, 24 per cent, is significant for the initiation of reactions to sound.

TABLE LIX
SOUND
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; STIMULUS, WOODEN BELL;
CONDITIONS ASLEEP AND DRY; SEPARATE AGE GROUPS
Number of infants—56

Sp.M. Gr.	B-1 d		2-4 d		5-7 d		8-10 d		11 d		Sum.	
	f	%	f	%	f	%	f	%	f	%	f	%
Hd.	0	0	1	1	0	0	1	1	2	5	4	1
Fa.	0	0	0	0	1	1	0	0	0	0	1	1
Bo.	6	22	16	20	19	28	25	30	13	31	79	26
Ext.	5	18	27	33	11	16	20	24	14	34	77	25
So.	1	4	1	1	2	3	1	1	1	2	6	2
Ey.	14	52	36	44	35	51	36	44	11	26	132	43
M.	0	0	1	1	0	0	0	0	1	2	2	1
Su.	1	4	0	0	1	1	0	0	0	0	2	1
T. f. ...	27		82		69		83		42		303	
%		9		27		23		27		14		100

Legend: Same as for Table LVI.

Table LIX shows:

1. That to the wooden bell stimulus, movements of the body 26 per cent, extremities 25 per cent, and eyes 43 per cent, are more numerous than all other forms of movement.

2. That the period 2-4 days, 27 per cent, is significant for the initiation of reactions to sound; but at 8-10 days the reactions are just as frequent, 27 per cent.

Table LX shows:

1. That to the electric bell stimulus, movements of the body 24 per cent, extremities 38 per cent, and eyes 30 per cent, are more numerous than all other forms of movement.

2. That the period 2-4 days, 28 per cent, is significant for the initiation of reaction to sound.

TABLE LX

SOUND

RELATION BETWEEN:

SPECIFIC MOVEMENT GROUPS; STIMULUS, ELECTRIC BELL
CONDITIONS ASLEEP AND DRY; SEPARATE AGE GROUPS

Number of infants—57

Sp.M. Gr.	B-1 d		2-4 d		5-7 d		8-10 d		11 d		Sum.	
	f	%	f	%	f	%	f	%	f	%	f	%
Hd.	0	0	1	1	0	0	4	3	1	1	6	1
Fa.	1	1	0	0	0	0	0	0	9	8	10	2
Bo.	22	28	39	24	32	27	26	22	23	23	142	24
Ext.	33	41	61	38	41	35	51	42	35	35	221	38
So.	1	1	2	1	11	9	4	3	7	7	25	4
Ey.	23	29	59	36	33	28	35	29	25	25	175	30
M.	0	0	0	0	0	0	0	0	0	0	0	0
Su.	0	0	0	0	1	1	1	1	1	1	3	1
T. f. ...	80		162		118		121		101		582	
%		14		28		21		20		17		100

Legend: Same as for Table LVI.

TABLE LXI

SOUND

RELATION BETWEEN:

SPECIFIC MOVEMENT GROUPS; STIMULUS, TUNING FORK;
CONDITIONS ASLEEP AND DRY; SEPARATE AGE GROUPS

Number of infants—59

Sp.M. Gr.	B-1 d		2-4 d		5-7 d		8-10 d		11 d		Sum.	
	f	%	f	%	f	%	f	%	f	%	f	%
Hd.	0	0	0	0	0	0	4	6	1	2	5	2
Fa.	0	0	1	4	1	2	0	0	0	0	2	1
Bo.	4	27	12	41	12	29	30	45	15	37	73	38
Ext.	9	60	11	38	16	38	13	20	16	39	65	34
So.	0	0	0	0	3	7	3	5	0	0	6	3
Ey.	2	13	5	17	10	24	16	24	9	22	42	22
M.	0	0	0	0	0	0	0	0	0	0	0	0
Su.	0	0	0	0	0	0	0	0	0	0	0	0
T. f. ...	15		29		42		66		41		193	
%		8		15		22		34		21		100

Legend: Same as for Table LVI.

Table LXI shows:

1. That to the tuning fork stimulus, movements of the body 38 per cent, extremities 34 per cent, and eyes 22 per cent, are more numerous than all other forms of movement.

2. That the period 2-4 days, 15 per cent, is significant for the initiation of reactions to sound, but for the tuning fork this value is less than for the other stimuli. The relatively high value of 34

per cent at 8-10 days seems to indicate that, if there is any differentiation between the reactions to noise and the reactions to tones, the noises are reacted to first.

TABLE LXII
SOUND
RELATION BETWEEN:
SPECIFIC MOVEMENTS; SEPARATE SOUND STIMULI;
CONDITIONS ASLEEP AND DRY; SEPARATE AGE GROUPS
Number of infants—59

Age	Can		Snap.		W.B.		E.B.		T.F.		Sum.	
	f	%	f	%	f	%	f	%	f	%	f	%
B-1 d	70	25	87	31	27	10	80	29	15	5	279	12
2-4 d	239	38	124	20	82	13	162	25	29	4	636	28
5-7 d	139	29	109	23	69	14	118	25	42	9	477	20
8-10 d	168	30	118	21	83	15	121	22	66	12	556	24
11 d	104	28	85	23	42	11	101	27	41	11	373	16
Total... Per cent	720	31	523	26	303	13	582	25	193	8	2321	100

Legend:

Stimuli. Can, snapper, wooden bell, electric bell, tuning fork.

f, frequency of specific movement groups as taken from Tables LVII to LXI.

%, centiles 100 (f/sum of f), for the corresponding age groups.

Sum. f, %, number and centiles for corresponding age groups.

T.f., %, total frequencies and centiles for the separate sound stimuli.

TABLE LXIII
SOUND
RELATION BETWEEN:
REACTION MEASURES; SEPARATE SOUND STIMULI;
CONDITIONS ASLEEP AND DRY; SEPARATE AGE GROUPS
Number of infants—59

Age	Can		Snap.		W.B.		E.B.		T.F.		Sum.	
	amt	%	amt	%	amt	%	amt	%	amt	%	amt	%
B-1 d	19	37	15	29	6	11	8	15	4	8	52	13
2-4 d	41	58	13	18	6	8	11	15	1	1	72	19
5-7 d	20	33	8	13	3	5	24	39	6	10	61	16
8-10 d	58	57	12	12	14	14	12	12	5	5	101	27
11 d	40	44	13	14	5	5	25	27	9	10	92	25
Total... Per cent	178	47	61	16	34	9	80	21	25	7	378	100

Legend:

Stimuli: Same as for Table LXII; Amt., millimeters of movement per stimulation of the stabilimeter pens for corresponding age groups; %, amt. expressed in centiles of the Sum.

Sum: Amt., total activity (millimeters) for corresponding age groups; %, amt. in centiles of the total for all ages.

Total: amount of activity for corresponding sounds; %, amt. in centiles.

Table LXII shows:

1. That for the group asleep and dry, the largest proportion of movements, 28 per cent, were for the age group 2-4 days. This was also the case for light (Table XXXIV).

2. That the largest number of reactions were to the can stimulus 31 per cent, and the fewest to the tuning fork 8 per cent.

Table LXIII shows:

1. That the amount of movement per stimulation was greatest at 8-10 days 27 per cent.

2. That the reactions to the can stimulus were strongest 47 per cent.

SUMMARY

1. To 59 infants there were given 461 tests, and 5,836 stimulations of the following order: can, snapper, wooden bell, electric bell, tuning fork.

2. The physiological conditions of the infants for the 461 tests were as follows: 54 per cent asleep and dry; 28 per cent asleep and wet; 9 per cent awake and dry; 8 per cent awake and wet (Table XLVII).

3. The infants reacted to 46 per cent of the stimulations; to 2 per cent they showed pacifying reactions (Table LIII).

4. The total number of specific movements was 4,374, giving an average of .7 reaction per stimulation (Table LIII).

5. The percentage of the measurable activity per stimulation as indicated by the stabilimeter records was as follows: 16 per cent at B-1 day; 18 per cent at 2-4 days; 20 per cent at 5-7 days; 22 per cent at 8-10 days; and 24 per cent at 11 days and older (Table LIII).

6. Of the activities recorded as specific movements, 35 per cent were movements of the extremities, 34 per cent were movements of the eyes, 26 per cent were general bodily movements, 3 per cent were sound reactions (some form of sound made by the infants), 1 per cent were facial movements, 1 per cent head movements (Table LVI).

7. An analysis of the reactions to the different auditory stimuli shows the following:

CAN (TABLE LVII):

(a) Of the reactions to the can, 41 per cent were of the extremities; 30 per cent of the body as a whole; 25 per cent of the eyes, and 4 per cent for all other movements.

(b) The reactions of the body as a whole were most pronounced at 8-10 days 48 per cent; those of the extremities at 2-4 days 46 per cent, and those of the eyes 5-7 days 32 per cent.

SNAPPER (TABLE LVIII):

(a) Of the reactions to the sound of the snapper, 47 per cent were reactions of the eyes; 31 per cent of the extremities; 18 per cent of the body as a whole; 4 per cent for all other movements.

(b) The reactions of the eyes were most pronounced at 5-7 days 58 per cent; those of the extremities at B-1 day 37 per cent, and 2-4 days 36 per cent; those of the body as a whole at B-1 day 25 per cent

WOODEN BELL (TABLE LIX):

(a) Of the reactions to the sound of the wooden bell, 43 per cent were reactions of the eyes; 26 per cent of the body as a whole; 25 per cent of the extremities; 6 per cent all other reactions.

(b) The reactions of the eyes were most pronounced for the younger age groups; those of the body as a whole for the older age groups.

ELECTRIC BELL (TABLE LX):

(a) Of the reactions to the sound of the electric bell, 38 per cent were reactions of the extremities; 30 per cent of the eyes; 24 per cent reactions of the body as a whole; 8 per cent all other reactions.

(b) The reactions of the eyes were most pronounced at 2-4 days, 36 per cent; those of the body as a whole at B-1 day 28 per cent.

TUNING FORK (TABLE LXI):

(a) Of the reactions to the sound of the tuning fork, 38 per cent were of the body as a whole; 34 per cent of the extremities; 22 per cent of the eyes; 6 per cent all other reactions.

(b) The reactions of the body as a whole were most pronounced at 8-10 days 45 per cent; those of the extremities at B-1 days 60 per cent; those of the eyes at 5-10 days 24 per cent.

8. Of the specific movements to the sound stimuli 31 per cent were to the can, 26 per cent to the snapper, 25 per cent to the electric bell, 13 per cent to the wooden bell, 8 per cent to the tuning fork (Table LXII).

9. Of the amount of measurable activity 47 per cent was to the can, 21 per cent to the electric bell, 16 per cent to the snapper, 9 per cent to the wooden bell, and 7 per cent to the tuning fork (Table LXIII).

10. The tendency for both the number of the reactions and specificity of the movements is to remain rather constant for all five age groups. This is supported by:

(a) The number of times the infants reacted to sound stimulation constituted 44 per cent at B-1 day; 46 per cent for 2-4, 5-7, and 11 days and older; 47 per cent for 8-10 days (Table LIII).

(b) The number of specific movements per stimulation was .7 at all age groups except that for 8-10 days (Table LIII).

11. The amount of measurable activity, however, as shown by the stabilimeter records increased 2 per cent for each age group (Table LIII).

12. The infant reactions to sound are only *partially* determined by the loudness of the stimuli as measured by adult reactions. This is supported by:

(a) The order of the relative loudness of the different sound stimuli ranges from the loudest to the faintest according to adult calibrations as follows: can, wooden bell and electric bell, snapper, tuning fork (Table XLV).

(*b*) According to the number of specific movements, for the infants the order is, can 31 per cent; snapper, 26 per cent; electric bell, 25 per cent; wooden bell, 13 per cent; tuning fork, 8 per cent (Table LXII).

(*c*) According to the amount of measurable activity, the order is can, 47 per cent; electric bell, 21 per cent; snapper, 16 per cent; wooden bell, 9 per cent; tuning fork, 7 per cent (Table LXIII).

The discrepancies between adult and infant reactions to sound seem to indicate a difference, but the results should be verified.

13. The analysis of the number of specific movements seems to suggest an explanation of the importance of the duration of the stimuli. This is supported by:

(*a*) The percentage of pacifying reactions to the tuning fork was 34 per cent, to the electric bell 34 per cent, to the snapper 19 per cent, to the can 12 per cent, to the wooden bell 3 per cent (Table LV). The order of the relative duration of the stimuli for adults is approximately the same.

14. Head movements tend to increase with age; 0 per cent at B-1 day, 3 per cent at 11 days and older (Table LVI).

15. The reactions to sound seem to be no more specific for sound than they are for other stimuli. This is supported by:

(*a*) The reactions of the head region (head, face, eyes), which constituted 36 per cent, while the reactions of the other parts of the body constituted 64 per cent (Table LVI).

(*b*) The analysis of the separate sound stimuli also supports this generalization (Tables LVII to LXI).

16. The analysis of the three factors (number of reactions, specificity of the reactions, amount of movement) shows that each type of sound stimulation has a stimulating effect of its own, but the variety and difference in force of the reactions was such that for these early ages the reactions to the type of stimuli used were not very specific. Further experiments on the separate variables, tone, noise, loudness, duration, would yield significant results for the auditory mechanism, which, as one of the factors of speech, becomes of such great importance at later ages.

CHAPTER V

REACTIONS TO TASTE

HISTORICAL

One of the earliest investigations of the reactions to taste stimuli was reported by Kussmaul (1859). He used a saturated sugar solution, sulphate of quinine in solution, salt, and tartaric acid. He reports sucking movements for sugar, and grimaces, which he describes as "grimaces of dislike" for the other three. Occasionally he found the facial expression to the sugar to be like that to bitter.

Preyer (1881), whose book *The Mind of the Child* is quoted in almost every review of experiments on children, also reported reactions to taste stimuli. He used sugar, salt, an acetic acid solution for the sour stimulation, and quinine for the bitter. He reports that in general, the newly born make a wry face after the introduction of a 3 to 5 per cent quinine solution; they shut the eyes tight, the throat is convulsively contracted, the mouth is opened wide, and the liquid is ejected along with the mucus of the mouth, which is generally secreted very scantily, but in this case abundantly. The "bitter" expression of the countenance is thus quite a different one from the "sweet," even on the first day of life (p. 121). He maintains also that the "sour" expression differs from the sweet and bitter. He noted individual differences in the reactions of various infants to these stimuli. These differences he explains in terms of "sensibility to degrees of intensity." What to one child tastes strong, tastes weak to another. Gustatory sensitiveness toward different degrees of intensity increases very early. On the second day, he reports that his child took without hesitation cow's milk diluted with water, but that on the fourth day he stoutly refused it.

Preyer believes that of all reactions those to taste stimuli are most highly developed in the newborn infant. He maintains that various "gustatory qualities are distinguished" by the newly born because they call forth different reflex movements.

He verified Kussmaul's results on taste, but added that, when he used diluted solutions of quinine and vinegar, some infants

reacted by sucking. He reports also that hungry infants are much more easily quieted by sucking their own fingers when they are one or two days of age than when they are a week old.

He does not give the strengths of his taste solutions, but if his 3 to 5 per cent quinine solution is an index of the strengths of the other solutions they were very strong indeed. For our infants we found very pronounced reactions to a 1-400 dilution.

Kroner (1881) was the first to emphasize the importance of the sense of taste. He believes that of all the senses the sense of taste is the one which is best developed at birth. His criterion is, as it was also for Kussmaul and Genzmer, the facial expression, which he reports as like that of the adult for the various solutions.

In sharp contrast to these descriptions of specific reactions in the newborn, we pass to the description of infant behavior as given to us by Miss Shinn (1900). Her reports are based on the observations of only one infant.

The senses of taste and smell, she believes, are in "an almost dormant condition" in the newborn. She comments on the look of contentment on the baby's face while it was nursing, and ascribes it to the "satisfaction of hunger." We read also "Many babies suck at a 2 per cent solution of quinine as if it were sugar; so it seems unlikely that the mild and monotonous taste of milk, and the neutral smells by which any well-kept baby is surrounded, are really perceived at all. There are instances related of very positive discrimination between one milk and another, either by taste or smell, shown by very young babies; yet the weight of evidence points to an almost dormant condition of these two senses" (p. 45).

The work of Peterson and Rainey (1910) is of importance because of the large number of cases which they observed. Greater significance could be attached to their results if they had used an objective method of experimentation.

For their taste experiments they used as stimuli: (1) a concentrated salt solution, (2) a 1 per cent solution of acetic acid, (3) syrup of unspecified strength, (4) tincture of gentian.

Results of these taste experiments are stated as follows: "An examination of 76 cases shows with regularity mimetic reactions

to the four stimuli characteristic of adults, grimaces of discomfort, or expressions of content. Sucking movements are not evidence of satisfaction, for they often accompanied the salt, sour, or bitter stimuli, but they would then be conjoined with expressions of dislike." These mimetic reactions were also observed in premature infants.

Canestrini (1913) reports experiments on taste. The solutions which he used were warmed to body temperature. He states that in the preliminary experimentation he was never able to observe that there was a difference in the reaction when the solutions were warmed to room temperature or to body temperature. Thirty-five infants were used, from 1-14 days of age. The same infant was sometimes used several times. The 95 single experiments which he performed were divided with regard to the stimuli used, as follows:

Sweet (2 to 5 per cent sugar solution)	37
Sour (2 to 5 per cent vinegar solution)	5
Salt (2 per cent salt solution)	14
Bitter (2 per cent quinine solution)	6
Cow's milk (diluted)	22
Mother's milk	5
Sucking without milk	6

The method which he used is not clearly described. He appears to have used applicators which were dipped into the taste solutions, and then inserted into the mouth of the infant.

Canestrini disagrees with the findings of Kroner as to the positive sucking reaction of infants to diluted solutions of quinine and vinegar ($\frac{1}{4}$ to 1 per cent) and states that these solutions would be so weak that adults could not react differentially to them. Moreover, the sucking reaction cannot be taken as the criterion of sensitivity to taste substances, since all solutions, and even a touch upon the lip areas will release sucking reactions.

He objects also to Preyer's contention that it is the new or strange taste substance that causes the reaction. Canestrini in his experiments frequently stimulated the infant, first with cow's milk, and immediately after with mother's milk, without observing a change in the reactions.

The latent time for the reactions to taste stimuli, he believes to be shorter in the newborn than that for any other sense impressions. This to him is an added proof of the great sensitivity of the taste end-organs at birth. This seems all the more remarkable in view of the fact that there has been no stimulation of this sense prior to birth, as there has been, for instance, of the touch end-organs. He believes that this remarkable development of the sense of taste has a survival value, protecting the infant from partaking of harmful substances.

Summary of Canestrini's Results on Taste:

1. The experiments performed in the four tastes (sweet, sour, salt, bitter) always produced a positive reaction.

2. Sweet stimulation produced a quieting effect upon the infant. Salt solution produced a slight restlessness, with cessation of sucking movements. Sour and bitter solutions always produced a decided irregularity in the breathing and fontanelle curves. These irregularities are caused by the head movements, movements of the extremities, and quickened breathing caused by crying.

3. Neither a qualitative nor a quantitative difference of reaction to the bitter and sour solutions could be established with certainty.

4. The reactions to taste stimuli are the most prompt of all reactions to sensory stimuli.

5. It was not possible to establish a differential reaction to cow's milk and mother's milk.

6. Every sucking movement was accompanied by a definite increase in the amplitude of the curves for the fontanelle pulsations.

Blanton (1917) aligns herself with that group of investigators who maintain that both taste and smell are in an almost dormant state at birth. "Taste and smell appear under normal conditions to be almost wholly wanting but can be excited by intensive artificial stimuli. There are also indications that taste, smell, and touch are not perfectly differentiated."

Drummond (1921) points out the difficulty of isolating the taste stimulus from smell, temperature, and touch. She also infers liking and disliking from the infant's behavior, but comes to different conclusions than do some of the other workers. For her the reaction to taste stimuli is a matter of the intensity of the

stimulus. "If we judge from the baby's behavior, any moderate taste stimulus is pleasant, even a fairly strong solution of quinine, is pleasant; a very strong stimulus is unpleasant, giving rise to grimaces and movements calculated to get rid of the offending substance" (p. 14).

From the evidence so far, it seems that the stronger the taste stimulus the stronger the reaction; although all of the investigators seemed to have used sour and bitter solutions which were very strong as compared with those used in this investigation. We started with what were relatively weak, sour, and bitter solutions, but we found that it was necessary to reduce even some of these in order to avoid coughing, wheezing, crying, and so forth. The sugar and salt, on the other hand, were relatively strong.

APPARATUS AND METHOD

It is extremely difficult to work out a satisfactory technique for applying taste stimuli. In order to make certain that the taste solution is actually stimulating the taste end-organs, it is necessary to touch the infant, and this, of course, brings an added source of stimulation into play. The method of stimulation used in this research was that of inserting into the infant's mouth, an applicator which had been dipped into the taste solution. It was found that a light touch at either corner of the infant's mouth would cause him to open his mouth and the applicator could then easily be inserted. The applicators used were the usual round stick nursery applicators, around one end of which was rolled a small bit of absorbent cotton. These were placed in a glass jar and sterilized. An applicator was used only once and then discarded.

The experiment was started with the following taste solutions, which were used from October 25 to November 13:

TABLE LXIV

Sugar 5 g.,	Water 30 g.....	17.0 per cent
Salt 5 g.,	Water 30 g.....	17.0 per cent
Quinine .3 g.,	Water 100 g.....	.3 per cent
Citric acid 3 g.,	Water 30 g.....	10.0 per cent
Distilled water was used as control.		

It is a difficult thing to estimate the stimulating strength of a solution. We first tried to make them subjectively equal in the

estimation of the experimenter N. However, because of the strong reactions of the infants to some of these taste stimuli (citric acid particularly) during the early experiments, some solutions were diluted to the proportions given in Table LXV. These solutions were kept at room temperatures varying from 20 to 27 degrees C.

TABLE LXV
CONCENTRATIONS OF TASTE SOLUTIONS

Sugar 5 g.,	Water 30 g.....	16.66 per cent
Salt 5 g.,	Water 60 g.....	8.33 per cent
Quinine .3 g.,	Water 120 g.....	.25 per cent
Citric acid 3 g.,	Water 140 g.....	2.14 per cent

Distilled water was used as control.

TABLES, DATA, AND RESULTS

TABLE LXVI
TASTE
SEX AND RACE DISTRIBUTION

	White	Black	Total
Male	6	8	14
Female	8	6	14
Total	14	14	28

TABLE LXVII
TASTE
RELATION BETWEEN:
SEPARATE CONDITIONS; SEPARATE AGE GROUPS
Number of infants—28

Age Days	N	As. Dr.		As. W.		Aw. Dr.		Aw. W.	
		f	%	f	%	f	%	f	%
0.....	4	3	75	1	25	0	0	0	0
1.....	16	13	81	1	6	2	13	0	0
2.....	19	12	63	3	16	4	21	0	0
3.....	13	8	62	1	8	3	23	1	7
4.....	15	13	86	1	7	1	7	0	0
5.....	15	9	60	3	20	2	13	1	7
6.....	19	11	60	5	26	2	10	1	4
7.....	14	5	36	8	57	1	7	0	0
8.....	20	6	30	9	45	3	15	2	10
9.....	20	10	50	7	35	1	5	2	10
10.....	23	9	39	9	39	3	13	2	9
11.....	22	12	55	6	28	4	17	0	0
12.....	14	9	64	3	21	0	0	2	15
13.....	6	3	50	1	14	1	13	1	13
14.....	5	4	80	0	0	1	20	0	0
15.....	2	1	50	1	50	0	0	0	0
Total.....	227	128		59		28		12	
Per cent...			57		26		13		4

Legend for Table LXVII:

N, number of tests for all conditions.

As., asleep; Aw., awake; Dr., dry; W., wet.

f, %, number and centiles of tests for corresponding headings.

Total, %, total number and centiles of totals for corresponding headings.

Table LXVII shows:

1. That the number of tests, 227, is greater than the number of infants, 28, because every infant was tested a number of times. The average number of tests is about 8, but this varied because of irregularities in the physiological conditions of the infants.

TABLE LXVIII

TASTE

RELATION BETWEEN:

REACTIONS; SEPARATE STIMULI; ALL CONDITIONS;

AGE GROUP, BIRTH TO 1 DAY

Number of infants—11

Stimulus	S N	R		Specific Movements			
				Sucking		Others	
		f	%	f	%	f	%
Sugar	19	18	95	17	49	18	51
Salt	15	9	60	6	26	17	74
Quinine	14	14	100	7	21	27	79
Citric	11	10	91	3	9	30	91
Water	15	13	87	6	32	13	68
Total	74	64		39		105	
Per cent			86		27		73

Legend:

Stim., The taste stimulations used. Sugar, salt, quinine, citric acid, distilled water, in the concentrations given in Table LXV.

S, N, number of stimulations.

R, reactions per stimulation. One reaction may include a number of specific movements. f, %, number and centiles.

Specific movements per stimulation. These have been divided into two groups: Sucking movements only; others, which include all movements except sucking. f, %, number and centiles of all specific movements.

Total, %, total number and centiles of totals for corresponding headings.

Table LXVIII shows:

1. That 11 infants, birth to 1 day, were given 74 taste stimulations, to which there were 86 per cent reactions.

2. Of the sucking reactions, 50 per cent are to sugar, 40 per cent to salt, 33 per cent to quinine, 23 per cent to citric acid, and 32 per cent to water.

3. Reactions other than sucking are most numerous for salt, quinine, and citric acid.

TABLE LXIX
TASTE
RELATION BETWEEN:
REACTIONS; SEPARATE STIMULI; ALL CONDITIONS;
AGE GROUP 2-4 DAYS
Number of infants—20

Stimulus	S N	R		Specific Movements			
		f	%	Sucking		Others	
Sugar	34	30	88	26	45	32	55
Salt	31	24	79	17	39	26	61
Quinine	25	21	84	13	27	36	73
Citric	22	21	95	4	6	59	94
Water	25	20	80	12	32	25	68
Total	137	116		72		178	
Per cent			85		29		71

Legend: Same as for Table LXVIII.

Table LXIX shows:

1. That for the age group 2 to 4 days, there were 85 per cent reactions. Of the specific movements 29 per cent were sucking movements, while 71 per cent were movements other than sucking.

2. That of the other movements, 36 per cent are to quinine, and 59 per cent to citric acid. To water there are 32 per cent movements, which indicates that the liquid (aside from taste) is a factor in reactions to taste.

3. That the reactions to sugar, 88 per cent, and citric, 95 per cent, were most numerous.

TABLE LXX
TASTE
RELATION BETWEEN:
REACTIONS; SEPARATE STIMULI; ALL CONDITIONS;
AGE GROUP 5-7 DAYS
Number of infants—18

Stimulus	S N	R		Specific Movements			
		f	%	Sucking		Others	
Sugar	46	42	87	33	60	22	40
Salt	44	39	89	31	51	30	49
Quinine	38	31	82	15	22	52	78
Citric	31	29	94	11	14	66	86
Water	34	28	82	15	33	30	67
Total	193	169		105		200	
Per cent			88		34		66

Legend: Same as for Table LXVIII.

Table LXX shows:

1. That 60 per cent of the specific movements to sugar were sucking reactions.
2. That most frequent reactions were to citric, 94 per cent. The specific movements were most numerous for quinine, 78 per cent, and citric acid, 86 per cent.
3. That citric caused fewest sucking movements, 14 per cent.

TABLE LXXI

TASTE

RELATION BETWEEN:

REACTIONS; SEPARATE STIMULI; ALL CONDITIONS;

AGE GROUP 8-10 DAYS

Number of infants—22

Stimulus	S N	R		Specific Movements			
				Sucking		Others	
		f	%	f	%	f	%
Sugar	61	55	90	48	58	35	42
Salt	58	45	78	30	39	47	61
Quinine	54	47	87	18	17	89	83
Citric	50	47	94	12	9	122	91
Water	51	43	84	25	30	57	70
Total	274	237		133		350	
Per cent			87		28		72

Legend: Same as for Table LXVIII.

Table LXXI shows:

1. That 58 per cent of the reactions to sugar were sucking.
2. That of the movements other than sucking, 91 per cent were to citric, and only 42 per cent to sugar.

TABLE LXXII

TASTE

RELATION BETWEEN:

REACTIONS; SEPARATE STIMULI; ALL CONDITIONS;

AGE GROUP 11 DAYS AND OLDER

Number of infants—17

Stimulus	S N	R		Specific Movements			
				Sucking		Others	
		f	%	f	%	f	%
Sugar	44	39	89	28	57	21	43
Salt	40	32	80	23	40	35	60
Quinine	37	27	73	11	19	47	81
Citric	26	23	88	8	4	71	96
Water	33	26	79	13	32	23	68
Total	180	147		78		202	
Per cent			81		28		72

Legend: Same as for Table LXVIII.

Table LXXII shows:

1. That there were 81 per cent reactions and that of these 28 per cent were sucking reactions.
2. That of the sucking reactions, 57 per cent were to sugar and only 4 per cent to citric.
3. That of other specific movements, the fewest are: 43 per cent to sugar, 40 per cent to salt, and 32 per cent to water.

TABLE LXXIII
TASTE
RELATION BETWEEN:
REACTIONS; ALL STIMULI; ALL CONDITIONS;
SEPARATE AGE GROUPS
Number of infants—28

Age	S N	R		Specific Movements			
		f	%	Sucking		Others	
B-1 d	74	64	86	39	27	105	73
2-4 d	137	116	85	72	29	178	71
5-7 d	193	169	88	105	34	200	66
8-10 d	274	237	87	133	28	350	72
11 d	180	147	81	78	28	202	72
Total	858	733		427		1035	
Per cent			85		29		71

Legend:

Age, B-1, Birth to 1 day; 2-4, second to fourth day; etc.

S, N, number of stimulations.

R, reactions per stimulation. One reaction may include a number of specific movements. f, %, number and centiles.

Specific Movements per stimulation. A detailed list is given in Table I. The specific movements have been divided into two groups: Sucking movements only; others, which include all movements except sucking.

Total, %, total number and centiles of the totals for the corresponding headings.

Table LXXIII shows:

1. That to a total of 858 taste stimulations there were 85 per cent reactions.
2. That 29 per cent of the reactions were sucking reactions and that these were rather constant for the two-weeks period for the stimuli used.
3. That the other specific movements to taste were rather high. This indicates that sucking is accompanied by many other movements and if the sucking reaction is to be rigidly defined, a great deal more than the mouth movements should be included.

4. The results seem to show that the sucking reaction is present at birth and remains rather constant during the first two weeks.

TABLE LXXIV

TASTE

RELATION BETWEEN:

SPECIFIC MOVEMENTS OTHER THAN SUCKING; SEPARATE STIMULI;

ALL CONDITIONS; SEPARATE AGE GROUPS

Number of infants—28

Stimulus	B-1 d		2-4 d		5-7 d		8-10 d		11 d		%
	St.	%	St.	%	St.	%	St.	%	St.	%	
Sugar	19	51	34	55	46	40	61	42	44	43	46
Salt	15	74	31	61	44	49	58	61	40	60	61
Quinine	14	79	25	73	38	78	54	83	37	81	79
Citric	11	91	22	94	31	86	50	91	26	96	92
Water	15	68	25	68	34	67	51	70	33	68	68
Av. %		73		71		66		72		72	

Legend:

St, %, number of stimulations and centiles as secured from Tables LXVIII to LXXII. Av., average centiles for corresponding stimuli.

Av. %, average of centiles for the corresponding age groups.

Table LXXIV shows:

1. That of the specific movements other than sucking, the reactions to sugar and salt are least, even less than to water. The reactions to citric acid were most pronounced.

2. That the period 5-7 days shows fewer specific movements to taste stimuli, 66 per cent, than any other period.

TABLE LXXV

TASTE

RELATION BETWEEN:

SUCKING REACTIONS; SEPARATE STIMULI;

ALL CONDITIONS; SEPARATE AGE GROUPS

Number of infants—28

Stimulus	B-1 d	2-4 d	5-7 d	8-10 d	11 d	Av.
	%	%	%	%	%	
Sugar	49	45	60	58	57	54
Salt	26	39	51	39	40	39
Quinine	21	27	22	17	19	21
Citric	9	6	14	9	4	8
Water	32	32	33	30	32	32
Av. %	27	30	36	31	30	

Legend:

%, Av., centiles and average centiles of sucking reactions for various stimuli.

Av. %, average of centiles for corresponding age groups.

Table LXXV shows:

1. That the sucking reactions to sugar were 54 per cent; to salt 39 per cent; to water 32 per cent; to quinine 21 per cent; and least of all to citric 8 per cent.

2. That the percentage of sucking reactions per stimulation is least for the group birth to 1 day 27 per cent; greatest at 5-7 days 36 per cent, and then decreases. This seems to indicate some improvement during the first week, but after this time the sucking reaction becomes more discriminating.

3. That for sugar there seems to be an increase from birth.

4. The frequency of the sucking reaction to taste stimuli is probably increased by the necessity of pressing the infant's cheek to get him to open his mouth. This touch alone causes a sucking reaction in 10 per cent of the cases (See Table CLII).

TABLE LXXVI
TASTE
RELATION BETWEEN:
SPECIFIC MOVEMENTS (SUCKING INCLUDED); SEPARATE STIMULI;
CONDITIONS, ASLEEP AND DRY; SEPARATE AGE GROUPS
Number of infants—26

Stimulus	B-1 d	2-4 d	5-7 d	8-10 d	11 d
	%	%	%	%	%
Sugar	18	22	18	24	18
Salt	14	17	22	22	25
Quinine	16	17	20	24	23
Citric	15	17	20	24	24
Water	12	16	19	29	24
Av. %	15	18	20	24	23

Legend:

%, centiles of number of specific movements for corresponding stimuli.

Av. %, average centiles for corresponding headings.

Table LXXVI shows:

1. That there is a gradual increase with age in the reactions to taste, 15 per cent of the reactions occurring at the age-level B-1 day, 18 per cent 2-4 days; 20 per cent 5-7 days; 24 per cent 8-10 days; 23 per cent at 11 days and older.

2. That the reactions to sugar do not show this gradual increase. At the age levels 2-4 days and 8-10 days, the specific reactions to sugar are greater than for the other age groups.

TABLE LXXVII
TASTE
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; SEPARATE STIMULI;
CONDITIONS, ASLEEP AND DRY; SEPARATE AGE GROUPS
Number of infants—26

Sp. M. Groups	Sugar %	Salt %	Quinine %	Citric %	Water %
Head	22	21	26	19	12
Face	9	15	34	25	17
Body	18	11	23	30	18
Extrem.	24	19	23	21	13
Sounds	8	13	22	54	3
Eye M.	25	8	25	34	8
Sucking	34	23	19	6	18
Mouth	6	17	19	47	11
Per cent	19	17	24	25	15

Legend:

Sp. M. Groups. Specific movement groups of the muscles of the head, face, body, extremities, sounds produced, eye movements, sucking, mouth movements (sucking omitted). See Table I for complete list of specific movements.

%, centiles for the corresponding headings.

Table LXXVII shows:

1. That of all the specific movements reported for the taste stimuli, 25 per cent are to citric acid, 24 per cent to quinine, 19 per cent to sugar, 17 per cent to salt, and 15 per cent to water.

2. That of the sucking movements, 34 per cent are to sugar, 23 per cent to salt, 19 per cent to quinine, 6 per cent to citric acid, 18 per cent to water.

3. That of the facial movements, the largest percentage is to citric acid and quinine.

TABLE LXXVIII
TASTE
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; ALL STIMULI;
CONDITIONS, ASLEEP AND DRY; SEPARATE AGE GROUPS
Number of infants—26

Age	Hd. %	Fa. %	Bo. %	Ex. %	So. %	Ey. %	M. %	Su. %
B-1 d	7	14	7	9	9	1	23	30
2-4 d	9	18	15	13	3	1	28	13
5-7 d	6	22	8	7	7	4	32	14
8-10 d	3	24	19	10	1	1	29	13
11 d	11	24	13	6	4	0	25	17
Av. %	6	21	12	9	4	1	28	19

Legend: Same as for Table LXXVII.

Table LXXVIII shows:

1. That the mouth, facial, and sucking movements constitute the largest group of reactions to taste stimuli.

2. That the sucking movements are most pronounced at the age level B-1 day, and again at 11 days and older.

3. That the movements of facial muscles increase from birth. These facts seem to confirm the results of other investigators who mention grimaces and other expressions as reactions to taste.

TABLE LXXIX

TASTE

RELATION BETWEEN:

SPECIFIC MOVEMENT GROUPS; STIMULUS, SUGAR;
CONDITIONS, ASLEEP AND DRY; SEPARATE AGE GROUPS
Number of infants—26

Age	Hd.	Fa.	Bo.	Ex.	So.	Ey.	M.	Su.
	%	%	%	%	%	%	%	%
B-1 d	10	7	3	17	3	3	13	44
2-4 d	8	11	17	19	0	0	6	39
5-7 d	11	13	13	4	4	4	0	51
8-10 d	5	9	16	5	0	3	5	57
11 d	8	14	10	10	3	0	3	52
Av. %	8	10	12	11	2	2	6	49

Legend: Same as for Table LXXVII.

Table LXXIX shows:

1. That of the reactions to sugar, 49 per cent are sucking reactions and 6 per cent mouth reactions, a total of 55 per cent.

2. That there is an increase in the percentage of sucking reactions to sugar from birth to the time the infant leaves the hospital.

TABLE LXXX

TASTE

RELATION BETWEEN:

SPECIFIC MOVEMENT GROUPS; STIMULUS, SALT;
CONDITIONS, ASLEEP AND DRY; SEPARATE AGE GROUPS
Number of infants—26

Age	Hd.	Fa.	Bo.	Ex.	So.	Ey.	M.	Su.
	%	%	%	%	%	%	%	%
B-1 d	9	9	0	20	14	0	24	24
2-4 d	7	15	7	15	3	0	15	33
5-7 d	3	22	3	3	0	3	16	50
8-10 d	6	25	9	13	0	0	13	34
11 d	14	19	17	2	2	0	14	32
Av. %	8	19	8	9	3	1	16	36

Legend: Same as for Table LXXVII.

Table LXXX shows:

1. That of the reactions to salt, 36 per cent are sucking reactions, 16 per cent are mouth reactions, and 19 per cent are facial reactions.
2. That the percentage of sucking increases from birth to the age level 5-7 days, at which time they constitute 50 per cent of the reactions, and then decrease again to 11 days and older.
3. That the percentage of mouth movements (exclusive of sucking) decreases from the time of birth to the last age level given.
4. That facial movements increase from birth.

TABLE LXXXI
TASTE
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; STIMULUS, QUININE;
CONDITIONS, ASLEEP AND DRY; SEPARATE AGE GROUPS
Number of infants—26

Age	Hd.	Fa.	Bo.	Ex.	So.	Ey.	M.	Su.
	%	%	%	%	%	%	%	%
B-1 d	11	27	6	0	6	0	30	20
2-4 d	9	20	14	9	6	3	9	30
5-7 d	7	30	7	13	7	6	7	23
8-10 d	0	35	17	13	2	0	11	22
11 d	15	30	16	7	0	0	16	16
Av. %	8	29	13	9	4	1	14	22

Legend: Same as for Table LXXVII.

Table LXXXI shows:

1. That of the reactions to quinine, 29 per cent are facial, 22 per cent are sucking, 14 per cent are mouth reactions, and 13 per cent are reactions of the body as a whole.
2. That the activity of the facial muscles increases with age, while the sucking reactions decrease.
3. At the age level B-1 day, the mouth and sucking reactions constitute 50 per cent of the reactions, and the head and face reactions 38 per cent. At the age level 11 days and older mouth and sucking constitute 32 per cent, while the head and face constitute 45 per cent of the reactions.

TABLE LXXXII

TASTE

RELATION BETWEEN:

SPECIFIC MOVEMENT GROUPS; STIMULUS, CITRIC ACID;
CONDITIONS, ASLEEP AND DRY; SEPARATE AGE GROUPS

Number of infants—26

Age	Hd.	Fa.	Bo.	Ex.	So.	Ey.	M.	Su.
	%	%	%	%	%	%	%	%
B-1 d	0	16	16	6	14	0	42	6
2-4 d	9	23	14	11	2	0	32	9
5-7 d	3	17	10	5	20	5	30	10
8-10 d	4	22	26	8	4	4	24	8
11 d	10	24	8	8	10	0	36	4
Av. %	5	21	15	8	10	2	32	7

Legend: Same as for Table LXXVII.

Table LXXXII shows:

1. That of the reactions to citric acid, 32 per cent were mouth reactions, 21 per cent facial reactions, 15 per cent reactions of the body as a whole, while 7 per cent were sucking reactions.
2. That there is a gradual increase with age in the facial reactions, while the sucking and mouth reactions decrease.
3. That the sucking reactions increase up to the age level 5-7 days and then decrease.

TABLE LXXXIII

TASTE

RELATION BETWEEN:

SPECIFIC MOVEMENT GROUPS; STIMULUS, WATER;
CONDITIONS, ASLEEP AND DRY; SEPARATE AGE GROUPS

Number of infants—26

Age	Hd.	Fa.	Bo.	Ex.	So.	Ey.	M.	Su.
	%	%	%	%	%	%	%	%
B-1 d	7	7	7	0	7	0	46	26
2-4 d	9	24	24	9	0	4	0	30
5-7 d	3	30	4	12	0	0	16	30
8-10 d	0	26	21	11	0	0	8	34
11 d	7	33	17	3	0	0	3	37
Av. %	5	26	16	8	1	1	11	32

Legend: Same as for Table LXXVII.

Table LXXXIII shows:

1. That of the reactions reported for water, 32 per cent are sucking, 26 per cent facial reactions, 16 per cent reactions of the body as a whole, 11 per cent mouth reactions.

2. That the sucking and mouth reactions are most pronounced at the age level B-1 day, while the face reactions increase from 7 per cent at B-1 day to 33 per cent at 11 days and older.

3. That the liquid form of stimulation by itself, even without a taste component, is an important stimulus in reactions to taste.

SUMMARY

FOR THE WHOLE GROUP (ALL PHYSIOLOGICAL CONDITIONS COMBINED)

1. To 28 infants there were given 227 tests, and 858 stimulations of the following taste solutions at room temperature: sugar, salt, quinine, water, and citric acid.

2. The physiological conditions of the infants during the 227 tests were as follows: 57 per cent asleep and dry; 26 per cent asleep and wet; 13 per cent awake and dry; 4 per cent awake and wet (Table LXXVII).

3. The infants reacted to 85 per cent of the stimulations (Table LXXIII).

4. At the age level birth-1 day, there were reactions to 86 per cent of the stimulations; at the age level 2-4 days 85 per cent; at 5-7 days 88 per cent; at 8-10 days 87 per cent; and at 11 days and older 81 per cent (Table LXXIII).

5. The percentage of specific reaction per stimulation is largest at the age level birth-1 day 73 per cent, and smallest at 5-7 days 66 per cent (Table LXXIV).

FOR THE GROUP "ASLEEP AND DRY"

6. Of the activities recorded as specific reactions, 19 per cent are sucking reactions; 9 per cent are movements of the extremities; 12 per cent are general body movements; 6 per cent are head movements; 21 per cent are facial movements; 28 per cent are mouth movements, exclusive of sucking; 4 per cent are mouth sounds; 1 per cent are eye movements (Table LXXVIII).

7. The sucking reactions are most pronounced at the age level birth-1 day 30 per cent, and decrease to 17 per cent for 11 days and older (Table LXXVIII).

8. The percentage of recorded body reactions increases from 7 per cent at birth to 13 per cent at the highest age group. Head reactions increase from 7 per cent at birth to 11 per cent for 11 days and older; facial reactions from 14 per cent to 24 per cent; other specific movements vary only slightly from birth to 11 days and older (Table LXXVIII).

9. Of the specific movements to gustatory stimuli, 25 per cent occurred to citric acid; 24 per cent to quinine; 19 per cent to sugar; 17 per cent to salt; and 15 per cent to water (Table LXXVII).

Water, which is supposed to be tasteless and which was used as control, released 15 per cent of the specific movements. If the taste reaction is the product of two stimuli, liquid plus a taste, then the component due to taste alone may be calculated by subtracting the percentage of the specific movements to water, 15 per cent, from the percentage of the specific movements to the taste stimuli. This gives citric acid 10 per cent, quinine 9 per cent, sugar 4 per cent, and salt 2 per cent. This would support the conclusion that taste is not well developed at birth for those strengths of stimuli used in these experiments.

10. When sucking is excluded, the infants reacted least to water and sugar.

11. Of the reactions to sugar, 49 per cent were sucking reactions; to salt 36 per cent; to water 32 per cent; to quinine 22 per cent; and to citric acid 7 per cent.

12. There is an indication of an increase in sucking reactions to sugar, from birth to 11 days and older (Table LXXIX), but a decrease to quinine and citric acid (Tables LXXX, LXXXI).

13. An analysis of the stimuli used shows the following:

SUGAR, 16.66 PER CENT (TABLE LXXIX)

(a) The most frequent reactions are sucking reactions. They constitute 49 per cent of all the reactions to sugar stimulation.

(b) There is an increase in the percentage of sucking reactions to sugar, from birth to the time the infant leaves the hospital.

SALT, 8.33 PER CENT (TABLE LXXX)

(a) Of the reactions to salt, 36 per cent are sucking reactions, 16 per cent are mouth reactions, and 19 per cent facial.

(b) The percentage of sucking reactions increases from birth on, to the age level 5-7 days, and then decreases again.

(c) There is an increase in facial movements from birth.

QUININE, .25 PER CENT (TABLE LXXXI)

(a) Of the reactions to quinine, 29 per cent are facial reactions, 22 per cent are sucking reactions, 14 per cent are mouth reactions, and 13 per cent are reactions of the body as a whole.

(b) The activity of the facial muscles increases with age, while the sucking reactions decrease.

CITRIC ACID, 2.15 PER CENT (TABLE LXXXII)

(a) Of the reactions to citric acid, 32 per cent were mouth reactions, 21 per cent facial reactions, 15 per cent reactions of the body as a whole, and 7 per cent sucking reactions.

(b) There is a gradual increase in the reactions of the facial muscles from birth on, while the sucking and mouth reactions decrease.

WATER (TABLE LXXXIII)

(a) Of the reactions reported for water, 32 per cent are sucking, 26 per cent facial, and 16 per cent reactions of the body as a whole.

(b) The sucking and mouth reactions are most pronounced at the age level B-1 day, while the face reactions increase from 7 per cent at B-1 day to 33 per cent at 11 days and older.

Infants do not react to taste solutions in the same way as adults. The final strength of citric acid solution used, 2.14 per cent, seemed rather weak for the adult experimenters. Yet the infants reacted strongly. To quinine 0.27 per cent the adult experimenters reacted strongly, while the infant reactions were relatively weak.

In general, when the taste solutions are of about equal strength and not too strong there is not much specificity in reaction. Where

strong specific reactions to taste solutions are reported, as by Peterson and Rainey (1910), the stimuli were probably very strong. They report that they used salt in a concentrated solution (actual strength not given). Anyone can soon convince himself that the reaction to a saturated salt solution is not the same as to 17 per cent solution.

From the results of these investigations, we are convinced that intensive stimuli for infants should not be used if a characteristic type of reaction to the particular stimulus is to be isolated. Furthermore, our work with quinine and citric acid shows that the reactions are not the same for infants as for adults.

By subtracting the results in Table LXXXIII from those in Tables LXXVIII to LXXXII, the resultant effects of the various stimuli may be derived. We did not do this on account of the fact that the data represent only one intensity of the stimulating substances. With only one value it is not safe to say that the effect of the quinine plus water stimulus can be reduced to the effect of quinine itself when the effect of the water is subtracted. The quinine stimuli should be given in at least three strengths, weak, medium, strong, before its effects can be safely determined. For quantitative work, eight or ten strengths should be used. We actually did this for temperature stimulations, but the reader can readily see that any increase in the intensities of the stimuli will extend the experimental period in proportion.

CHAPTER VI

REACTIONS TO SMELL

HISTORICAL

One of the earliest experiments on the reaction of infants to olfactory stimuli is reported by Kussmaul (1859). For his odor stimuli he used *asafoetida*, *oleum dippelii*, acetic acid, and ammonia fumes. He experimented only on infants in sleep. The first two, he reports, are unpleasantly perceived, while the effect of ammonia and acetic acid he believed to be due to tactile stimulation rather than olfactory.

Preyer (1881) presents conflicting statements on reactions to smell. He repeated Kroner's experiment of rubbing petroleum upon the breast of the mother, and confirms Kroner's findings that the infant refused to take the breast. He adds the comment that children sometimes refuse to take the breast of a nurse whose skin has a disagreeable smell. He states further that the fact that many infants only a few days of age refuse to take cow's milk after they have had the breast must be ascribed to the smell rather than the taste, since they sometimes refuse the milk when it is brought near them without tasting it. However, he also states that it is improbable that the sense of smell is concerned in the sucking of the nipple, and says that his own child often sucked in the wrong place. His final conclusion regarding the sense of smell is that it is not of great importance for infants.

He considers stimulation of the infant with ammonia fumes and acetic acid vapor as an irritation of the mucus membrane of the nose. The reactions to these two stimuli are described as violent sneezing, or corrugation of the forehead, or at least blinking, and sometimes rubbing of the face with the hands. He secured the same reactions to smell stimuli as did the previous investigators mentioned. When he used *asafoetida* as a stimulus, he reports crying and sucking reactions.

Tanner (1904) reports that the newborn infant does not react as strongly to stimuli of all kinds as does a child a month old. She

agrees with Preyer that the sense of smell does not develop so rapidly as do the other senses.

Peterson and Rainey (1910) also experimented with these odors: (1) asafoetida, (2) compound spirits of orange, (3) tincture of gentian, (4) oil of rose geranium, (5) mothers' milk.

In opposition to the investigators who hold that the sense of smell is almost dormant at birth, these authors state that the olfactory nerve is sensitive to odors practically at birth. The reactions are quickening of respiration, grimaces, squirming, crying, and sucking movements. In one case these reactions were observed 15 minutes after birth; in 10 cases, within the first hour of life.

One of the best experiments on smell was performed by Canestrini (1913). He calls attention to the generally accepted views of some of the early authors who maintained that the sense of smell is highly developed in the newborn human infant. He thinks this belief is probably derived from the fact that the sense of smell in lower animals is highly developed. These authors also point to the early myelination of the olfactory and gustatory fibers of the brain, which they correlate with early functioning of these fibers. He quotes Preyer as saying that the normal child distinguishes several kinds of milk at an early age, with the help only of the sense of smell, and is capable at the age of one day of distinguishing several odors with certainty. He quotes also the work of Kussmaul and Kroner, who favor the view that the sense of smell plays an important rôle in the life of the newborn.

In his own experiments he was careful to avoid any form of stimulation other than smell. The infants were not stimulated tactually, as was the case with so many of the earlier forms of experimentation. His list of stimuli included twenty odorous chemicals, among which were asafoetida, oil of cloves, camphor, vinegar, lavender, chloroform, musk, absinthe, oil of peppermint, amyl nitrite, and oil of turpentine. The method of stimulation was either to soak a cotton applicator with the odorous solution and hold it under the infant's nostril, or to put the solution in a bottle and hold the bottle under the nostril. There were 101 separate experiments, yielding 47 positive, and 54 negative results. These experiments were performed under varying conditions; that is,

some of the infants were awake, some asleep, some restless, some quiet. Negative results were obtained in 66 per cent of the experiments with asafoetida, in 84 per cent of the cases in which vinegar was used, whereas such substances as absinthe and musk served as a rather strong stimulation.

Canestrini comes to the conclusion that infants react most strongly to those olfactory stimuli which stimulate the "trigeminal components of the sense of smell," thus making it a tactual rather than an olfactory stimulation.

Summary of his results on smell:

1. Of all the sensory systems, the sense of smell seems to be the least active in the newborn infant. He agrees with Rousseau's contention that in most infants the sense of smell is very dull, indicating probably a degeneration of these organs in the human race.

2. The majority of the olfactory stimuli produced no change, either in the breathing curves or fontanelle curves.

3. Those substances which did serve to stimulate the infant produced an increase in the fontanelle pulsations, increased respiration, deeper and more irregular breathing.

4. When lukewarm milk was used as an olfactory stimulus, no positive results could be obtained. He disagrees with Preyer's contention that infants refuse to take cow's milk because of the smell, and holds that it must be taste that causes this refusal.

5. Bad-smelling substances occasionally had a quieting effect upon a crying infant.

Drummond (1921) doubts whether or not there are at birth any clearly defined smell sensations. "If we experiment with odorous substances, we get reactions which are very similar to those obtained from taste stimuli. Under normal conditions there is probably no smell experience. It is probable that early smell experience is confused with taste. It is only by slow degrees that the two senses are differentiated" (p. 14).

Peiper (1924) presents results on the temperature and smell experiments which are in agreement with those of Canestrini. Regarding the sense of smell, he concludes that it is more difficult to stimulate this sense than any of the others.

The olfactory pump consists essentially of a container (1 qt.) partly filled with water into which a tube *C* of known capacity is lowered at the instant of stimulation. This forces the vapor-laden air in the smell capsule (Fig. 8) into one of the nostrils of the infant.

The outer container *A* is a can 15 x 10.7 cm. Into the top is inserted a loosely fitting wooden lid *B* 2½ cm. thick.

A brass tube *C*, 2½ cm. inside diameter, 15 cm. long, is inserted through a loosely fitting opening in top *B*. The distance to which it is raised and lowered is controlled by appropriate stops.

The outlet *D* is a glass tube leading into a rubber tube, which connects with the odor capsule (Fig. 8).



FIG. 8. Olfactory Capsule.

E is a fiber plug inserted into the top of tube *C* with a close fit. The lines *b* and *a* represent flapper valves made of thin dental rubber and attached as shown. These are really check valves which allow the air to pass only in one direction. When the tube *C* sinks into the water, this closes valve *b* and opens *a* thus allowing the air which is displaced by the sinking to pass through *a*, then through *D*, and finally through the odor capsule. Raising the tube opens *b* and closes *a*. The distance is so regulated that 20 cc. of air pass through the capsule at each stimulation.

The capsules (Fig. 8) are made of glass tubes fitted with corks in the ends as shown in the illustration. There is a capsule for each odor. At the beginning of each experimental period one of the corks was removed and a tuft of cotton was placed in the capsule. Upon this cotton were placed two drops of the odorous

solution. This was then covered with another bit of cotton and the cork again replaced. The capsule was then ready to be used.

The following solutions were used in the strengths given:

TABLE LXXXIV

Valerian	2 drops
Acetic acid	2 drops
Oil of cloves	2 drops
Ammonia	2 drops
(5 cc. of 28 per cent ammonia in 25 cc. water)	

The odor substances soon evaporated producing a saturated vapor in the capsule. When connected with the olfactory pump, 20 cc. of this vapor were blown into the nostril of the infant at each stimulation. As a control a capsule containing only cotton (without odor) was used. This stimulation is called "Air" in the tables.

The technique of applying the olfactory stimuli was as follows: The experimenter held the glass capsule in such a position that the curved glass tip was as close as possible to the infant's nostril, nearest the experimenter. With the other hand he released the cord which held the piston tube of the olfactory pump. When this tube plunged into the water in the can, the vaporized odor in the capsule was blown into the nostril. This was done three times for each stimulus, with 4.5 seconds rest between stimulations.

The curved glass tips were changed once every week and sterilized. A supply of sterile tips was always on hand so that if the experimenter accidentally touched the infant the tip was changed.

Since this technique does not necessitate the touching of the infant, reaction measures of the activity could be added for this group of tests. If the stimulus occurred at a time when the infant was already restless and squirming, the stabilimeter was not used. The general rule was to count only those records where no movement had been recorded immediately preceding the stimulation.

TABLES, DATA AND RESULTS

The reactions to smell stimuli were studied on 48 infants, the race and sex distribution of which are shown in Table LXXXV.

TABLE LXXXV
SMELL
SEX AND RACE DISTRIBUTION

	White	Black	Total
Male	9	12	21
Female	16	11	27
Total	25	23	48

TABLE LXXXVI
SMELL
RELATION BETWEEN:
SEPARATE CONDITIONS; SEPARATE AGE GROUPS
Number of infants—48

Age Days	T N	As. Dr.		As. W.		Aw. Dr.		Aw. W.	
		f	%	f	%	f	%	f	%
0.....	10	8	80	0	0	2	20	0	0
1.....	23	21	90	1	5	1	5	0	0
2.....	30	22	73	5	17	3	10	0	0
3.....	31	18	58	6	19	5	16	2	7
4.....	30	20	67	6	20	3	10	1	3
5.....	32	17	53	11	35	2	6	2	6
6.....	39	23	59	12	31	2	5	2	5
7.....	33	17	51	14	43	2	6	0	0
8.....	32	22	70	9	28	0	0	1	2
9.....	28	17	61	7	25	2	7	2	7
10.....	50	15	50	8	27	2	6	5	17
11.....	22	14	64	5	23	3	13	0	0
12.....	17	8	47	4	24	3	17	2	12
13.....	9	5	56	2	22	1	11	1	11
14.....	8	7	88	0	0	1	12	0	0
15.....	3	2	67	1	33	0	0	0	0
21.....	1	1	100	0	0	0	0	0	0
Total	378	237		91		32		18	
Per cent..			63		24		9		4

Legend:

N, number of tests for all conditions. Each test included 3 stimulations.

As., asleep; Aw., awake; Dr., dry; W., wet.

f, %, number and centiles of tests for conditions indicated.

Table LXXXVI shows:

1. That 378 experiments were made, and that the conditions were distributed as follows: 63 per cent asleep and dry; 24 per cent asleep and wet; 9 per cent awake and dry; 4 per cent awake and wet.

2. There were approximately 8 tests per infant. Some infants were taken as many as 14 times, while some were taken only 2 or 3 times. No routine could be followed because of the irregularity of the physiological conditions.

TABLE LXXXVII

SMELL

RELATION BETWEEN:

REACTIONS; REACTION MEASURES; SEPARATE STIMULI;
ALL CONDITIONS; AGE GROUP, BIRTH TO 1 DAY

Number of infants—17

Stimulus	S N	R.		Sp. M.		Stab. R.		
		f	%	f	Av.	Amt.	Av.	%
Val.	62	35	56	52	.84	91	1.46	5
Ac.	46	43	93	123	2.67	621	18.50	44
Clo.	66	16	24	20	.80	29	.44	1
Amm.	39	37	95	109	2.79	597	15.30	49
Air	60	2	3	2	.03	23	.38	1
Total	273	133		306		1361	81.08	100
% or Av.			49		1.12		5.00	

Legend:

Stimuli: Val., Valerian; Ac., acetic acid; Clo., Oil of cloves; Amm., ammonia; Air (used as control).

S. N., number of stimulations.

R., reactions. These reactions were usually made up of a number of specific movements. f, number of reactions per stimulation; %, value of f in centiles.

Sp. M., specific movements. A detailed list is given in Table I. f, number of specific movements; av., average number per stimulation.

Stab. R., stabilimeter record: amt., amount of movement in millimeters of the stabilimeter pens; av., average amount in millimeters per stimulation (amt./N); %, activity per stimulation in centiles 100 (av./sum of avs.).

Table LXXXVII shows:

1. For the age group B-1 day there were 93 per cent reactions to acetic acid; 95 per cent reactions to ammonia; 56 per cent to valerian; 24 per cent to cloves; 3 per cent to air (the control).

2. The average number of specific movements per stimulation were to acetic acid, 2.67; ammonia, 2.79; valerian, .84; cloves, .30; and air, the control stimulus, .03.

3. The stabilimeter record shows 44 per cent movement for acetic acid; 49 per cent to ammonia; and 7 per cent for all other stimuli, divided as follows: valerian 5 per cent, and cloves and air each 1 per cent.

4. The total number of stimulations was 273. To these stimulations there were 133 reactions, or 49 per cent; an average of 1.12 specific movements; 5.0 millimeters of activity. To 51 per cent of the stimulations, there were no reactions.

TABLE LXXXVIII

SMELL

RELATION BETWEEN:

REACTIONS; REACTION MEASURES; SEPARATE STIMULI;

ALL CONDITIONS; AGE GROUP 2-4 DAYS

Number of infants—30

Stimulus	S N	R.		Sp. M.		Stab. R.		
		f	%	f	Av.	Amt.	Av.	%
Val.	165	83	50	140	.85	331	2.00	5
Ac.	121	100	83	243	2.00	1350	11.16	31
Clo.	161	52	32	82	.51	223	1.38	4
Amm.	110	70	64	198	1.80	2329	21.17	59
Air	154	24	16	88	.25	31	.20	1
Total	711	329		701		4264	35.91	100
% or Av.			47		.98		5.00	

Legend: Same as for Table LXXXVII.

Table LXXXVIII shows:

1. That for the age group 2-4 days, there were 83 per cent reactions to acetic acid; 64 per cent to ammonia; 50 per cent to valerian; 32 per cent to cloves, and 16 per cent to air.

2. That of the activity indicated by the stabilimeter record, 59 per cent is for ammonia, 31 per cent for acetic acid, 5 per cent for valerian, 4 per cent for cloves, and 1 per cent for the control, air.

3. That of the specific movements, the largest averages are reported for ammonia and acetic, valerian being the next in order.

TABLE LXXXIX

SMELL

RELATION BETWEEN:

REACTIONS; REACTION MEASURES; SEPARATE STIMULI;

ALL CONDITIONS; AGE GROUP 5-7 DAYS

Number of infants—33

Stimulus	S N	R.		Sp. M.		Stab. R.		
		f	%	f	Av.	Amt.	Av.	%
Val.	186	76	41	133	.71	261	1.40	4
Ac.	119	104	87	262	2.20	1505	12.65	36
Clo.	181	74	41	97	.54	210	1.16	3
Amm.	122	94	77	240	1.97	2403	19.70	55
Air	181	35	19	66	.36	107	.59	2
Total	789	383		798		4486	35.50	100
% or Av.			49		1.01		5.68	

Legend: Same as for Table LXXXVII.

Table LXXXIX shows:

1. That for the age group 5-7 days, there were 87 per cent reactions to acetic acid; 77 per cent to ammonia; 41 per cent to valerian; 41 per cent to cloves; and 19 per cent to air.

2. That of the activity indicated by the stabilimeter record, 55 per cent is for ammonia; 36 per cent for acetic acid; 4 per cent for valerian; 3 per cent for cloves; and 2 per cent for air.

3. The greatest average of specific movements per stimulation was 2.2 to acetic acid and 1.97 to ammonia. The smallest amount of movement occurred to air, the control stimulus.

TABLE XC
SMELL
RELATION BETWEEN:
REACTIONS; REACTION MEASURES; SEPARATE STIMULI;
ALL CONDITIONS; AGE GROUP 8-10 DAYS
Number of infants—28

Stimulus	S N	R.		Sp. M.		Stab. R.		
		f	%	f	Av.	Amt.	Av.	%
Val.	147	65	44	116	.79	135	.92	3
Ac.	108	84	78	221	2.05	1238	11.46	32
Clo.	142	69	49	93	.65	180	1.27	3
Amm.	104	71	68	189	1.82	2280	21.44	60
Air	143	41	29	36	.25	98	.68	2
Total	644	330		655		3881	35.77	100
% or Av.			51		1.02		6.03	

Legend: Same as for Table LXXXVII.

Table XC shows:

1. That for the age group 8-10 days there were 78 per cent reactions to acetic acid; 68 per cent to ammonia; 49 per cent to cloves; 44 per cent to valerian; and 29 per cent to air.

2. The average number of specific movements per stimulation was 2.05 for acetic; 1.82 for ammonia; for valerian .79; for cloves .65; for air .25.

3. The stabilimeter record shows 60 per cent movement to ammonia; 32 per cent to acetic acid; 3 per cent to cloves; 3 per cent to valerian; and 2 per cent to air.

4. There was a total number of 644 stimulations, to which there were 330 reactions, or 51 per cent.

TABLE XCI

SMELL

RELATION BETWEEN:

REACTIONS; REACTION MEASURES; SEPARATE STIMULI;
ALL CONDITIONS; AGE GROUP 11 DAYS AND OLDER

Number of infants—13

Stimulus	S N	R.		Sp. M.		Stab. R.		
		f	%	f	Av.	Amt.	Av.	%
Val.	78	33	42	57	.73	131	1.68	8
Ac.	65	47	72	120	1.85	398	6.12	29
Clo.	78	21	27	29	.37	17	.22	1
Amm.	55	31	56	84	1.53	656	11.93	58
Air	75	24	32	36	.48	56	.75	4
Total	351	156		326		1258	20.70	100
% or Av.			44		.93		3.58	

Legend: Same as for Table LXXXVII.

Table XCI shows:

1. That for the age group 11 days and older there were 72 per cent reactions to acetic acid; 56 per cent to ammonia; 42 per cent to valerian; 32 per cent to air; and 27 per cent to cloves.

2. The average number of specific movements per stimulation is greatest for acetic acid, 1.85; ammonia 1.53.

3. The stabilimeter record shows 58 centiles of movement for ammonia; 29 per cent for acetic acid; 8 per cent for valerian; 4 per cent for air; and 1 per cent for cloves—less than air alone!

4. That the average energy per specific movement is largest for ammonia, 11.93; and smallest for cloves, .22.

TABLE XCII

SMELL

RELATION BETWEEN:

REACTIONS; ALL STIMULI; ALL CONDITIONS;
SEPARATE AGE GROUPS

Number of infants—34

Age	S N	R.		Sp. M.		Stab. R.		
		f	%	f	Av.	Amt.	Av.	%
B-1 d	273	133	49	306	1.12	1361	4.98	19
2-4 d	711	329	47	701	.98	4264	6.00	23
5-7 d	789	383	49	798	1.01	4486	5.68	22
8-10 d	644	330	51	655	1.02	3881	6.03	23
11 d	351	156	44	326	.93	1258	3.58	13
Total	2768	1331		2786		15250	26.27	100
% or Av.			48		1.01		5.52	

Legend: Same as for Table LXXXVII.

Table XCII shows:

1. That the percentage of reactions is about the same for all age groups.

2. There were 48 per cent reactions, which indicates that about half the olfactory stimuli were without effect. The average number of specific movements per stimulation is 1.01, which indicates that on the average two specific movements were reported for each reaction.

3. That the amount of activity as indicated by the centiles in the stabilimeter record does not change a great deal during the first two weeks. While there seems to be a progressive increase in coördination with age, the crying during the first week is often so violent, for short periods, that a great deal of energy is expended.

TABLE XCIII
SMELL
RELATION BETWEEN:
SPECIFIC MOVEMENTS; SEPARATE STIMULI; ALL
CONDITIONS; SEPARATE AGE GROUPS
Number of infants—34

Stimulus	B-1 d		2-4 d		5-7 d		8-10 d		11 d	
	f	Av.	f	Av.	f	Av.	f	Av.	f	Av.
Val.	52	.84	140	.85	133	.71	116	.79	57	.73
Ac.	123	2.67	243	2.00	262	2.20	221	2.05	120	1.85
Clo.	20	.30	82	.51	97	.54	93	.65	29	.37
Amm.	109	2.79	198	1.80	240	1.97	189	1.82	84	1.53
Air	2	.03	38	.25	66	.36	36	.25	36	.48
Total.....	306		701		798		655		326	
Av.		1.33		1.08		1.16		1.12		.99

Legend:

f, number of specific movements as in Table I.

av., number of specific movements per stimulation.

Table XCIII shows:

1. That the largest average of specific movements released by olfactory stimulation occurred at the age level B-1 day 1.33; and that from that time on there is a decrease to .99 specific movements per stimulation. This may possibly indicate an adaptation to the olfactory stimulations.

2. That acetic and ammonia produced the greatest number of movements at all age levels, and cloves and air the least.

TABLE XCIV
SMELL
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; STIMULUS VALERIAN;
CONDITIONS, ASLEEP AND DRY; SEPARATE AGE GROUPS
Number of infants—33

Age	Hd.	Fa.	Bo.	Ex.	So.	Ey.	M.	Su.
	%	%	%	%	%	%	%	%
B-1 d	8	6	26	12	0	12	0	36
2-4 d	15	6	25	26	5	6	3	14
5-7 d	13	4	36	21	4	11	0	11
8-10 d	8	7	34	28	4	16	0	3
11 d	4	6	33	31	10	12	0	4
Av. %	10	6	30	24	5	11	1	13

Legend:

Age, B-1 d., Birth to 1 day; 2-4 d., 2 to 4 days, etc.

Specific reaction groups. Hd., head movements; Fa., facial movements; Bo., trunk movements; Ex., movements of arms and legs; So., the production of sounds; Ey., eye movements; M., mouth movements (not including sucking); Su., sucking reaction.

%, centiles of specific movements for the corresponding age (these percentages should add to 100 horizontally).

The number of stimulations has not been considered. The table shows only the composition of those reactions that were actually made.

Table XCIV shows:

1. That of the reactions to the odor of valerian, 30 per cent were of the body as a whole; 24 per cent were of the extremities; and 13 per cent were sucking reactions.

2. That the sucking reactions to valerian were most pronounced at the age level B-1 day, constituting at that time 36 per cent of all reactions, and that sucking reactions decreased with age.

TABLE XCV
SMELL
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; STIMULUS ACETIC ACID;
CONDITIONS, ASLEEP AND DRY; SEPARATE AGE GROUPS
Number of infants—33

Age	Hd.	Fa.	Bo.	Ex.	So.	Ey.	M.	Su.
	%	%	%	%	%	%	%	%
B-1 d	13	12	19	31	11	5	2	7
2-4 d	14	12	21	29	13	3	2	6
5-7 d	19	14	30	20	7	3	5	2
8-10 d	14	10	25	32	9	5	2	3
11 d	16	14	29	14	10	3	10	4
Av. %	15	12	25	26	10	4	4	5

Legend: Same as for Table XCIV.

Table XCV shows:

1. That the order of the reactions to the odor of acetic acid is 26 per cent reactions of the extremities; 25 per cent of the body as a whole; 15 per cent head reactions, 12 per cent facial reactions, 10 per cent sounds, and 5 per cent sucking reactions.

2. That the sucking reactions show a decrease from birth.

TABLE XCVI
SMELL
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; STIMULUS OIL OF CLOVES;
CONDITIONS, ASLEEP AND DRY; SEPARATE AGE GROUPS
Number of infants—33

Age	Hd.	Fa.	Bo.	Ex.	So.	Ey.	M.	Su.
	%	%	%	%	%	%	%	%
B-1 d	15	0	35	10	5	10	5	20
2-4 d	4	2	32	32	4	11	0	15
5-7 d	8	10	46	18	3	10	3	2
8-10 d	10	1	34	21	3	24	3	3
11 d	0	0	53	12	17	6	0	12
Av. %	8	3	39	21	5	14	2	8

Legend: Same as for Table XCIV.

Table XCVI shows:

1. That the order of the reactions to cloves is 39 per cent reactions of the body as a whole; 21 per cent reactions of extremities; 14 per cent reactions of the eyes; and 8 per cent each of sucking and head reactions.

TABLE XCVII
SMELL
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; STIMULUS AMMONIA;
CONDITIONS, ASLEEP AND DRY; SEPARATE AGE GROUPS
Number of infants—33

Age	Hd.	Fa.	Bo.	Ex.	So.	Ey.	M.	Su.
	%	%	%	%	%	%	%	%
B-1 d	15	5	24	31	14	0	6	5
2-4 d	12	5	23	32	20	3	0	5
5-7 d	12	11	27	32	12	3	1	2
8-10 d	12	7	30	28	19	2	1	1
11 d	9	13	23	21	12	11	9	2
Av. %	12	8	26	30	16	3	2	3

Legend: Same as for Table XCIV.

Table XCVII shows:

1. That the order of reactions to ammonia is 30 per cent reactions of the extremities, 26 per cent reactions of the body as a whole; 16 per cent sounds, 12 per cent head movements, 8 per cent facial reactions, and 3 per cent sucking reactions.

2. That the sucking reactions show a decrease from the time of birth.

TABLE XCVIII
SMELL
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; STIMULUS AIR;
CONDITIONS, ASLEEP AND DRY; SEPARATE AGE GROUPS
Number of infants—33

Age	Hd.	Fa.	Bo.	Ex.	So.	Ey.	M.	Su.
	%	%	%	%	%	%	%	%
B-1 d	50	0	50	0	0	0	0	0
2-4 d	0	0	15	54	0	23	0	8
5-7 d	0	3	44	13	0	30	0	10
8-10 d	0	0	37	33	0	30	0	0
11 d	0	0	31	19	19	28	0	3
Av. %	1	1	34	25	6	28	0	5

Legend: Same as for Table XCIV.

Table XCVIII shows:

1. That the order of reactions to the control stimulus air, is: 34 per cent body movements; 28 per cent eye movements; 25 per cent movements of the extremities.

TABLE XCIX
SMELL
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; SEPARATE STIMULI;
CONDITIONS, ASLEEP AND DRY; ALL AGES
Number of infants—33

Stimulus	Hd.	Fa.	Bo.	Ex.	So.	Ey.	M.	Su.
	%	%	%	%	%	%	%	%
Val.	10	6	30	24	5	11	1	13
Ac.	15	12	25	26	10	4	4	5
Clo.	8	3	39	21	5	14	2	8
Amm.	12	8	26	30	16	13	2	3
Air.	1	1	34	25	6	28	0	5
Av. %	8	9	30	25	10	7	2	7

Legend: Same as for Table XCIV.

Table XCIX shows:

1. That the order of the reactions to odors is: 30 per cent body reactions; 25 per cent movements of the extremities; 10 per cent mouth sounds; 9 per cent facial movements; 8 per cent head movements; 7 per cent each for eye movements and sucking movements; 2 per cent mouth movements exclusive of sucking.

2. That valerian and cloves released more sucking reactions than did acetic acid and ammonia.

TABLE C
SMELL
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; ALL STIMULI COMBINED;
CONDITIONS, ASLEEP AND DRY; SEPARATE AGE GROUPS
Number of infants—33

Age	Hd.	Fa.	Bo.	Ex.	So.	Ey.	M.	Su.
	%	%	%	%	%	%	%	%
B-1 d	13	8	23	26	9	5	3	13
2-4 d	12	7	24	30	12	5	1	9
5-7 d	12	11	33	24	8	5	3	4
8-10 d	12	7	30	28	11	9	1	2
11 d	10	11	30	20	11	7	7	4
Av.%	13	9	28	26	10	6	3	5

Legend: Same as for Table XCIV.

Table C shows:

1. That the order of the reactions to all the odor stimuli is: 28 per cent general body movements; 26 per cent movements of the extremities; 13 per cent head movements; 10 per cent mouth sounds; 9 per cent facial movements; 6 per cent eye movements; 5 per cent sucking reactions; 3 per cent mouth movements exclusive of sucking.

2. That the sucking movements are most numerous at birth to 1 day, 13 per cent, and decrease with increase in age.

Table CI (on p. 141) shows:

1. That 59 per cent of the activity was to ammonia; 32 per cent to acetic acid; 5 per cent to valerian; 3 per cent to cloves; and 1 per cent to air.

2. That the activity aroused by stimulation with the control, air, shows an increase from the time of birth on.

TABLE CI
SMELL
RELATION BETWEEN:
REACTION MEASURES; SEPARATE STIMULI;
CONDITIONS, ASLEEP AND DRY; SEPARATE AGE GROUPS
Number of infants—33

Age	Val.		Ac.		Clo.		Amm.		Air	
	Amt.	%	Amt.	%	Amt.	%	Amt.	%	Amt.	%
B-1 d	14	5	115	40	5	2	153	53	0	0
2-4 d	24	5	129	29	17	4	272	61	1	1
5-7 d	23	5	140	33	13	3	243	57	6	1
8-10 d	9	3	99	29	6	1	224	65	8	2
11 d	15	7	62	28	3	1	132	59	10	5
Total	85		545		44		1024		25	
Av. %		5		32		3		59		1

Legend:

Odors: Val., valerian; Ac., acetic acid; Clo., oil of cloves; Amm., ammonia; air.

Amt., millimeters per stimulation (stabilimeter record).

%, amount in centiles.

SUMMARY

FOR THE WHOLE GROUP (ALL PHYSIOLOGICAL CONDITIONS COMBINED)

1. To 48 infants there were 378 tests to stimulations of the following odors: valerian, acetic acid, oil of cloves, and ammonia. A puff of air was used as a control.

2. The physiological conditions of the infants were as follows: 63 per cent asleep and dry; 24 per cent asleep and wet; 9 per cent awake and dry; 4 per cent awake and wet (Table LXXXVI).

3. The infants reacted to 48 per cent of the stimulations (Table XCII).

4. For the age group, birth-1 day, there were 49 per cent reactions; at 2-4 days 47 per cent; at 5-7 days 49 per cent; at 8-10 days 51 per cent; and at 11 days and older 44 per cent (Table XCII).

5. The number of specific movements per stimulation is largest for the age group birth-1 day 1.12; and smallest for the age group 11 days and older .93 (Table XCII).

FOR THE GROUP "ASLEEP AND DRY"

6. Of the specific movement groups, 28 per cent are general body movements; 26 per cent are movements of the extremities; 13 per cent are head movements; 10 per cent mouth sounds; 9 per cent are facial movements; 6 per cent are eye movements; 5 per cent are sucking reactions; and 3 per cent are mouth movements exclusive of sucking (Table C).

7. The sucking reactions are most pronounced for the age group birth-1 day, 13 per cent; and decrease to 4 per cent at 11 days and older (Table C).

8. The centiles of body movements increase from 23 per cent at birth to 30 per cent for the highest age group. Mouth sounds increase from 3 per cent at birth to 7 per cent. Other specific movements vary only slightly from birth to 11 days and older (Table C).

9. Of the activity to olfactory stimuli, there was 59 per cent to ammonia; 32 per cent to acetic acid; 5 per cent to valerian; 3 per cent to cloves; and 1 per cent to air (Table CI).

10. Sucking reactions to valerian were 13 per cent; to cloves 8 per cent; to acetic acid 5 per cent; air 5 per cent; ammonia 3 per cent (Table XCIX). For all of the olfactory stimuli used, the sucking reactions decrease from birth (Table C). The reactions to the separate stimuli were as follows:

VALERIAN (TABLE XCIV)

(a) Of the reactions to valerian, 30 per cent were of the body as a whole; 24 per cent were of the extremities; and 13 per cent were sucking reactions.

(b) The sucking reactions to valerian were most pronounced at birth and decreased rapidly with age.

ACETIC ACID (TABLE XCV)

(a) Of the reactions to acetic acid, 26 per cent are movements of the extremities; 25 per cent of the body as a whole; 15 per cent are head reactions; 12 per cent are facial reactions; 10 per cent are sounds; and 5 per cent are sucking reactions.

CLOVES (TABLE XCVI)

(a) Of the reactions to cloves, 39 per cent are of the body as a whole; 21 per cent are of extremities; 14 per cent are of the eyes; 8 per cent each of sucking and head reactions.

AMMONIA (TABLE XCVII)

(a) Of the reactions to ammonia, 30 per cent are reactions of the extremities; 26 per cent of the body as a whole; 16 per cent are sounds; 12 per cent are head movements; 8 per cent are facial movements; and 3 per cent are sucking reactions.

(b) The sucking reactions decrease from birth.

AIR (TABLES XCVIII AND XCI)

(a) Of the reactions to the control stimulus air, 34 per cent are body reactions; 28 per cent movements of the eyes; 25 per cent movements of the extremities; 6 per cent sounds; 5 per cent sucking reactions; and 1 per cent each of head and facial movements (Table XCVIII).

(b) The puff of air without the odor component is a form of stimulation for the older infants. The activity to oil of cloves, 1 per cent, was less than to air alone, 4 per cent. To valerian the activity was slightly more, 8 per cent (Table XCI).

The results on smell stimuli confirm the conclusions from light and sound reactions, namely, that the newborn infant does not react to stimuli in the same way as do adults. Thus, to the experimenters, the ammonia seemed much stronger than the acetic acid, while the infant reactions were about equal to both of these stimuli.

CHAPTER VII

REACTIONS TO TEMPERATURE

HISTORICAL

The experiments on temperature are rather meager. One finds many references to the thermal reactions of infants, but so many factors, such as age, health, temperature, and the like, are omitted that it is practically impossible to verify the results.

Genzmer (1873) repeated some of Kussmaul's experiments, and added some of his own. He used fifty newborn babies. According to his reports, touch was found to be the most highly developed sense at birth. In his temperature tests, he used only cold stimuli, one of which was a cold iron rod, the other was secured by wetting the skin and blowing on it. He stated that this sort of stimulus, applied to the side of the foot, produced withdrawal of the foot; applied to the hollow of the hand, it produced closing, then withdrawal of the hand. When the cheek was cooled the head was turned to one side.

Kroner (1881) states that the infants are clearly sensitive to cold and warmth.

Preyer (1881), in *The Mind of the Child*, presents a detailed account of the reactions of his son to various stimulating conditions, from birth to the end of his third year. He was with the child at least three times a day. He states that the mucus membrane of the mouth, the tongue, and the lips of many infants is surprisingly sensitive to cold and warmth during the first days. If the nursing bottle is a little more than blood warm, it is refused, often with violent screaming; and if it is some degrees colder than the milk sucked from the breast of the mother, it is refused likewise. He suggests that, in the experiments on taste, the liquids used should have a temperature of 37 degrees C. He adds, however, that infants learn easily to drink water and milk of the temperature of the room they live in, if their drink is always given at this temperature. He tried also to cool the bath water of his child gradually. He found that it could be reduced to 32.50 degrees C. without "lessening the child's pleasure." However, when

it was lowered to 31.25 degrees C. or lower, the child "screamed until warmer water was added."

Tanner (1904) states only in very general terms that infants show pleasure in a warm bath, and displeasure when the water is slightly cooler. He does not suggest an optimum temperature.

Canestrini (1913) applied the following forms of stimulation:

- Touching certain parts of the body with the fingers
- Touching certain parts of the body with an applicator
- Touching the lips with various objects
- Cold stimulation with ethylchloride, alcohol, cold metal
- Blowing upon the infant
- Pin pricks
- Galvanic current (up to 10 milliamperes)
- "Faradischer Strom"

Summary of his results:

1. Cold stimuli produced the most prompt and most pronounced reactions.

2. These reactions were: increased respiration; increased brain volume, as shown by the fontanelle curves; restlessness; and occasionally increased pulse rate.

Margaret Blanton (1917), a pupil of Watson, reports some observations on infants during the first thirty days of life. On temperature changes she has the following to say, "I have noted six occasions on which there was marked shivering within fifteen minutes of birth; on two occasions it persisted until the infant was brought near to a hot-water bottle for some time. The skin of this baby was cold to the touch. The shivering was so pronounced as to make a marked movement of the toothless lower jaw, which under other conditions we call 'chattering'" (p. 475). Concerning the effect of heat she says, "Uncovering the lower part of the infant's body to the heat of a mild fire caused curling of the toes both upward and downward."

Regarding the temperature sense, Drummond (1921) says only that cold is felt as unpleasant. This again is inferred from behavior changes.

Peiper (1924) reports that the reactions of the infants to cold stimulation were very pronounced. The breathing curves became very irregular, and were influenced by the bodily movements elicited by the cold stimulation.

TABLES, DATA, RESULTS

Two forms of stimulation were used:

1. Stimulation by a cold cylinder applied to forehead and to inside surface of the knee most conveniently exposed.
2. Stimulation by water at different temperatures introduced into the mouth by a medicine dropper.

RESULTS OF STIMULATION ON FOREHEAD AND KNEE

At the beginning of the experiment we tried to use a number of different temperatures; but, owing to the time consumed and difficulty in maintaining the cylinders at a uniform temperature, as well as the fact that no reaction was obtained to temperatures around 33 degrees and 45 degrees C., these were discontinued, only the "cool" cylinder being retained. This temperature was secured by melting ice in a beaker. The temperature of the stimulus cylinder ranged from 5 degrees to 20 degrees C, the average being around 11 degrees or 12 degrees C. When ready for stimulation, the cylinder was withdrawn from the solution of melting ice, and either put into a flannel jacket or wrapped in a cloth before application. The size of the stimulating area was 50 square millimeters, and the metal was copper.

TABLE CII
TEMPERATURE
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; STIMULUS, COLD ON FOREHEAD;
CONDITION, ASLEEP; SEPARATE AGE GROUPS
Number of Infants—21

Age Days	N	R	Head Back	Gasp	Shudder	Other
		%	%	%	%	%
0	4	100	75	25	0	50
1	8	73	75	25	0	13
2	2	67	100	0	0	0
3	7	78	100	0	0	0
4	8	73	75	0	0	38
5	5	71	60	20	40	20
6	6	67	33	17	0	50
7	5	71	60	60	0	0
8	4	57	75	75	0	0
9	6	86	50	50	17	33
10	5	88	40	40	20	20
11	2	50	50	50	0	50
12	2	67	0	100	50	0
13	2	100	50	50	0	50
Av. %		73	64	30	7	23

Legend for Table CII:

N, number of experiments. This may include more than one stimulation.

R, reactions per stimulation expressed in centiles.

Hd. Bk., head moved backward out of the way.

Gasp, Shudder (self explanatory).

Other, specific movements that were not classified. They may be in addition or part of the reaction listed.

Av. %, average centiles for the corresponding headings.

Table CII shows:

1. That there were 73 per cent reactions to cold on the forehead when infants were asleep.
2. That the most frequent reaction was that of throwing the head back 64 per cent.

TABLE CIII
TEMPERATURE
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; STIMULUS, COLD ON FOREHEAD;
CONDITION AWAKE; SEPARATE AGE GROUPS
Number of Infants—21

Age Days	N	R	Head Back	Gasp	Shudder	Other
		%	%	%	%	%
0	5	71	80	20		20
1	4	80	25			75
2	3	50	67			33
3	4	67	25			75
4	3	60	33	33		33
5	2	100	50			100
6	2	100	100			
7	6	75	67	17		33
8	6	100	50		50	17
9	2	50	50			50
10	1	50				100
11	3	75	33	33	33	33
12	2	67	50	50		
13	1	50	100			100
14	0	0				
Av. %		68	52	11	9	41

Legend. Same as for Table CII.

Table CIII shows:

1. That there were 68 per cent reactions to cold on forehead when the infants were awake.
2. That the most frequent reaction was that of throwing back the head 52 per cent.
3. The gasping reaction occurred to 11 per cent and the shudder to 9 per cent of the stimulations.
4. At the age level of 5, 6, and 8 days the infants reacted to every stimulation.

TABLE CIV
TEMPERATURE
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; STIMULUS, COLD ON LEG;
CONDITION, ASLEEP; SEPARATE AGE GROUPS
Number of Infants—21

Age Days	N	R	Fl.	Ex.	Gasp	Other
		%	%	%	%	%
0	4	100	100			
1	10	91	70	10		30
2	3	100	100			33
3	9	100	55	33		11
4	11	100	46	27		18
5	6	86	33	67		17
6	6	75	67	17		17
7	5	71	80			20
8	7	100	71	14		14
9	6	86	67	17		17
10	6	100	83	17		
11	4	100	75	25	50	
12	2	67	100			
13	2	100	100			50
Av. %		91	68	20	2	16

Legend:

N, number of experiments.

R, reactions per stimulation expressed in centiles.

Fl, flexion of leg at hip (bringing leg against stimulus).

Ex, extension of leg at hip (moving leg away from stimulus).

Gasp, gasping reactions.

Other, centiles of reactions other than those given.

Av. %, average centiles for corresponding headings.

TABLE CV
TEMPERATURE
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; STIMULUS, COLD ON LEG;
CONDITION AWAKE; SEPARATE AGE GROUPS
Number of Infants—21

Age Days	N	R	Fl.	Ex.	Gasp	Other
		%	%	%	%	%
0	6	85	17	33		50
1	5	100	80			20
2	6	85	67			33
3	6	100	17	67		17
4	5	100	60	40		20
5	1	100	100			
6	2	100	100			
7	7	86	56	19	14	23
8	6	100	17	17		67
9	4	100	100			
10	2	100	50			50
11	3	75	33	67		
12	3	100	100			
13	2	100	100			
14	1	100	100			
17	2	100	50			
Av. %		93	53	21	2	24

Legend: Same as for Table CIV.

Table CIV shows:

1. That there were 91 per cent reactions to cold on leg, when infants were asleep.
2. That 68 per cent reactions were flexing of the leg; 20 per cent were leg extensions.

Table CV shows:

1. That there were 93 per cent reactions to cold on leg when infants were awake.
2. That 53 per cent were flexions, and 21 per cent were leg extensions.

Tables CII to CV of the preliminary investigation show:

1. That infants are about as sensitive to cold when awake 68 per cent, 93 per cent reactions, as when asleep 73 per cent, 91 per cent reactions.
2. That the "Other" reactions make up about one-fourth of the movements, indicating that the reaction to cold is one of the most specific reactions.
3. That the reaction is segmental or near to the point of stimulus application. To cold on forehead there were 64 per cent and 52 per cent head movements. To cold on leg there were flexion 68 per cent, extension 20 per cent, or 88 per cent when asleep; and when awake there were flexion 53 per cent, extension 21 per cent, or together 74 per cent.
4. Gasping is more frequent with head stimulation, forehead-asleep 30 per cent, forehead-awake 11 per cent; leg-asleep 2 per cent, leg-awake 2 per cent.

RESULTS OF STIMULATION BY WATER OF DIFFERENT TEMPERATURES, APPLIED IN MOUTH

The results secured with temperature cylinder applied to forehead and leg were unsatisfactory in many respects. There were not enough steps in the temperature scale; the temperature of the cylinder itself was too variable; the temperature of the point of application, forehead and leg, was not uniform; trouble with the stimuli and method of application occurred too frequently.

We therefore constructed a temperature-regulating device

which was automatic in its action and gave a series of temperature steps. To secure more uniformity in the temperature of the area of application, we selected the mouth and tongue and used distilled water as a stimulus.

APPARATUS AND METHOD

A temperature apparatus was so constructed as to contain eight compartments filled with water, each maintaining its own constant temperature by an individual heating unit controlled by a thermostat.

Eight different temperatures were used: 8 degrees C., 13 degrees C., 18 degrees C., 23 degrees C., 33 degrees C., 43 degrees C., 48 degrees C., 53 degrees C. Each compartment held a one-ounce bottle with medicine dropper instead of a cork.

The temperature-regulating unit, Figure 9, is an isometric drawing of the apparatus viewed from the top. It is a unit by itself having separate supports so that it can be moved from place to place.

The external frame of the temperature-regulating unit (35.4 x 45.5 x 17.5 cm.) is made of poplar wood and is partitioned into 8 sections by walls 12 mm. thick. Each section contains two rectangular varnish cans of two different sizes, an inner can inserted within the larger outer can. The inner can holds about a quart of water, the temperature of which is controlled. More specifically, the water in the first can is held at a temperature of 8 degrees C., the second 13 degrees C., the third 18 degrees C., the fourth 23 degrees C., the fifth 33 degrees C., the sixth 43 degrees C., the seventh 48 degrees C., and the eighth 53 degrees C.

A is a brass outlet stand pipe, 17.5 cm. in height and 2.5 cm. in diameter, having an operating outlet and a drain outlet.

B is a brass inlet stand pipe of the same size as *A*, having also an operating outlet. Details are shown in Figure 10.

C and *D* are hoods (45.5 x 17.5 x 6.5 cm.) which cover the electrical and thermostatic connections when the apparatus is in use. They are hinged and can be thrown backward, out of the way, when making adjustments.

E is another hood (48.2 x 17.5 x 11.5 cm.) which covers the eight relays and their connections.

The whole temperature unit is mounted upon a special table to bring the height of the water-baths to convenient handling position.

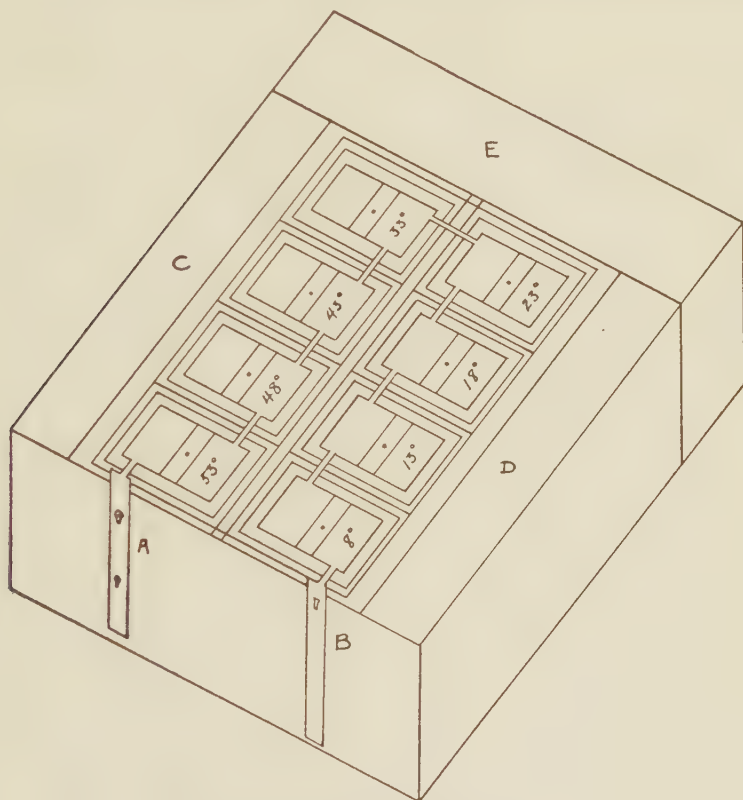


FIG. 9. Temperature-regulating unit showing top view of compartments containing water-baths.

LIQUID RELATIONS

The principle is that of starting with ice water and gradually heating this as it passes from one compartment to another, until it has reached the maximum temperature of 53 degrees C. In this

way electric current is saved and the unit can be put into operating condition in about fifteen minutes.

Ice water (of about 6-7 degrees C.) supplies the water-baths in a serial order. It is held in a six-gallon container situated on a table (not shown in the diagram) about a foot higher than the temperature-regulating unit. The flow of the ice water is indicated by arrows in Figure 10. The coldest water flows first into the lowest temperature unit and then passes through successively higher temperatures.

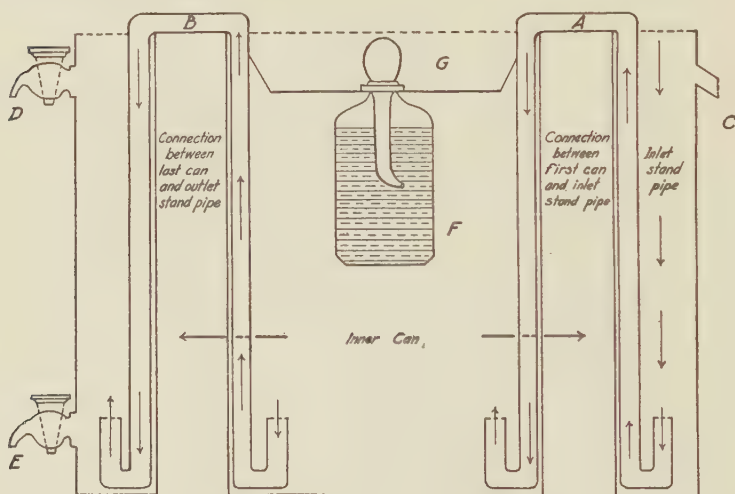


FIG. 10. Temperature fluid flow, showing inlet and outlet stand pipes, with siphons.

The interconnections between the cans and the stand pipes are controlled by 9 siphons made of lead pipes 8 mm. bore and 33.5 cm. long bent as shown. In Figure 10 only two of them *A* and *B* are shown, the one *A* between the inlet stand pipe and the first can, and the other *B* between the outlet stand pipe and the last can.

The operating outlet *C* of the inlet stand pipe and that *D* of the outlet stand pipe are always open for drainage in case of an oversupply of water, or in case a siphon gets stalled. The drain outlet *E* is closed before and during use, and is opened for drainage of the system when the experimental period is over.

In each can is suspended a two-ounce medicine bottle *F* with a medicine dropper *G* filled with distilled water. This bottle is the stimulus source, and its temperature is maintained by the water-bath in which it is suspended. In stimulating infants the medicine dropper only is removed, and a measured amount is squirted into the mouth or on the skin.

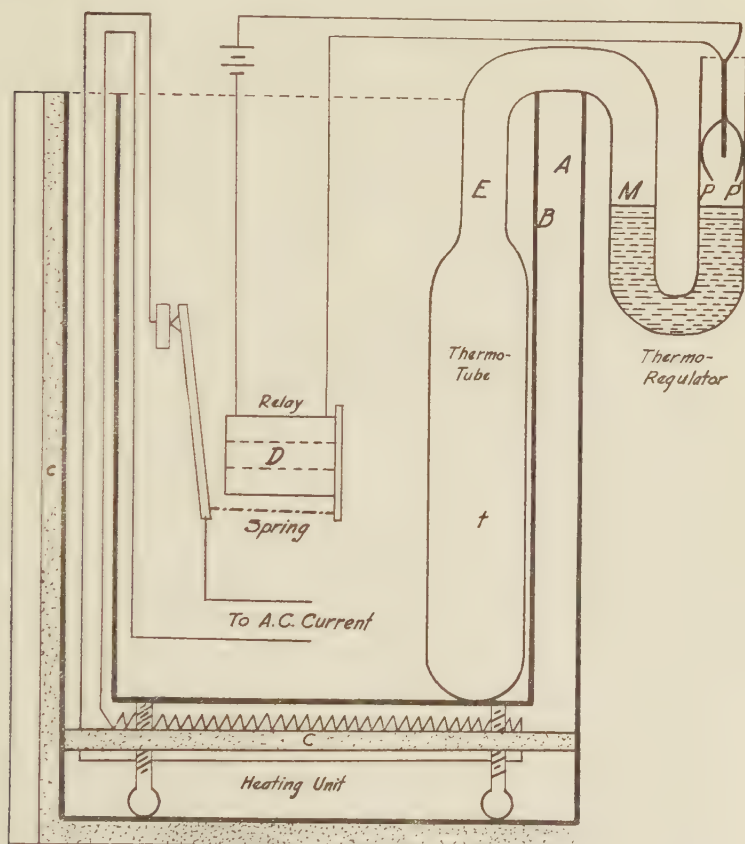


FIG.11. Electrical and Thermostatic Connections. This drawing shows only one compartment.

ELECTRIC AND THERMOSTATIC CONNECTIONS

Each of the other seven compartments contains the same equipment, except that all the relays are brought together into a single unit at the end of the apparatus under *E*, Figure 9. Each compartment has its separate heating coils. The water enters at a lower temperature through one siphon and leaves at the compartment temperature through another siphon. This produces convection currents which tend to keep the water in circulation.

A is a half-gallon rectangular varnish can 9 x 18 x 9.2 cm. with the top cut off. Each can is insulated from the other cans or the walls of the apparatus by an asbestos sheet 3 mm. thick and a wooden partition 12 mm. thick.

B is a quart rectangular varnish can 10.3 x 15 x 6.8 cm. with the top cut off, into which has been fitted a thin brass water-tight can. This brass insert was found necessary because the changes in temperature soon rust the iron cans.

C is an asbestos sheet 3 mm. thick between the bottoms and the side of partitions. Four screws hold *B* and *C* in position. On the one-quarter-inch asbestos sheet *C* has been mounted a manganin heating wire with one terminal leading directly to one of the A. C. terminals. We used about 7 meters of No. 17 manganin wire for each heating unit. The resistance of the coil was about 75 ohms when cold.

D is the relay having its magnet terminals connected with two small copper springs (*p*, *p'*) well insulated from each other and firmly held in the thermostatic U tube. *E* is the glass thermo-regulator in which *M* is the mercury and *t* the expansion fluid toluene. When the water reaches the proper temperature, the mercury level rises and makes contact between the points *p* and *p'*. This breaks the A. C. current passing through the relay to the heating coil. The range in temperature regulation is one degree above or below the temperature for which the heating unit is adjusted. Each of the eight temperature units has one of these heating devices. The relays are all mounted together at the end of the apparatus. The ordinary telegraph relay is too large and bulky. The thermo-regulator is run by a 6-volt storage battery of the radio type.

The electrical heating unit and the thermo-regulator: The relay armature is under the tension of a spring thus closing the A. C. circuit. This heats the water, and when it reaches the proper temperature several processes occur, in the following order:

1. t , the expansion fluid toluene, begins to expand.
2. The expansion of t causes a rise in M , the mercury.
3. M comes into contact with the points p and p' of the two copper springs and completes the relay magnet circuit.
4. The relay coil D pulls back the armature and breaks the A. C. circuit.
5. When the temperature begins to fall, all the foregoing processes are reversed and the heater is again automatically thrown into action.

Each temperature is automatically controlled in this manner by its own heating unit and thermo-regulator, and each compartment functions independently of all the others.

The technique of applying the stimuli was that of filling the dropper with distilled water at the temperature of the given compartment, opening the infant's mouth by a gentle pressure on its chin, and then dropping from 5 to 6 drops of the water on the tongue of the opened mouth by pressing on the rubber end of the dropper. No attempt was made to determine the temperature of the water at the instant it stimulated the tongue. As soon as the medicine dropper is removed from the water bath, it begins to cool and the amount of cooling (or warming for the lower temperature) depends on the room temperature and the original temperature. We tried to maintain a uniform interval between removing the dropper from the water-bath and dropping the water on the tongue. This interval varied between 9 and 13 seconds because sometimes the infants did not open their mouths as promptly as was expected by the experimenter. When the delay was too long, the dropper was returned to the water-bath and a different temperature was used.

The temperature tests were introduced on January 26, and continued throughout the remainder of the investigation. On this same date, the taste experiments were eliminated. As experimentation progresses there is a tending to enlarge the program. It would

be desirable to have all infants for all the experiments, but as soon as intensive work is started on even one form of stimulation, it is practically impossible to include anything more than a "control period."

The tests were given to 30 infants, of which the race and sex frequencies are shown in Table CVI.

TABLES, DATA, RESULTS

TABLE CVI
TEMPERATURE
SEX AND RACE DISTRIBUTION

	White	Black	Total
Male	8	6	14
Female	10	6	16
Total	18	12	30

TABLE CVII
TEMPERATURE
RELATION BETWEEN:
SEPARATE CONDITIONS; SEPARATE AGE GROUPS
Number of Infants—30

Age Days	N	As. Dr.		As. W.		Aw. Dr.		Aw. W.	
		f	%	f	%	f	%	f	%
0	9	8	89	0	0	1	11	0	0
1	14	13	93	0	0	1	7	0	0
2	16	13	81	1	7	2	12	0	0
3	19	14	73	5	27	0	0	0	0
4	19	14	73	4	21	1	6	0	0
5	22	12	54	8	37	0	0	2	9
6	22	10	45	11	50	0	0	1	5
7	27	15	56	11	41	0	0	1	3
8	18	15	83	3	17	0	0	0	0
9	18	13	73	3	17	1	5	1	5
10	12	6	50	4	34	1	8	1	8
11	9	7	78	1	11	1	11	0	0
12	5	2	40	2	40	1	20	0	0
13	4	3	75	1	25	0	0	0	0
14	5	4	80	0	0	1	20	0	0
15	1	1	100	0	0	0	0	0	0
20	1	0	0	0	0	0	0	1	100
21	1	1	100	0	0	0	0	0	0
Total	222	151		54		10		7	
Per cent....			68		24		5		3

Legend:

N, number of tests for all conditions.

As., asleep; Aw., awake; Dr., dry; W., wet.

f. %, number and centiles of tests for conditions indicated.

Table CVII shows:

1. That to 30 infants there were given 222 tests, and that the conditions of these infants were as follows: 68 per cent asleep and dry; 24 per cent asleep and wet, 5 per cent awake and dry, 3 per cent awake and wet.

TABLE CVIII
TEMPERATURE
RELATION BETWEEN:
REACTIONS; SEPARATE STIMULI; ALL CONDITIONS;
AGE GROUP BIRTH TO 1 DAY
Number of Infants—15

Stimulus	S	R		Sp. M.	
	N	f	%	f	Av.
8	17	17	100	59	3.47
13	19	19	100	54	2.84
18	18	18	100	54	3.00
23	16	16	100	36	2.25
33	17	15	88	22	1.29
43	20	18	90	26	1.30
48	20	20	100	39	1.95
53	15	13	87	34	2.27
Total	142	136		324	
% or Av. ...			96		2.28

Legend:

Stim., the temperatures in degrees centigrade.

S, N, number of stimulations.

R, reactions per stimulation. One reaction may include a number of specific movements.

f., %, number and centiles.

Sp. M., specific movements per stimulation. A detailed list is given in Table I.

f, %, av., number, centiles, and average movements per stimulation.

Table CVIII shows:

1. That for the age group birth to 1 day there were 96 per cent reactions.

2. That the largest number of specific movements were to the temperatures 8 degrees, 13 degrees, 18 degrees, 23 degrees, 48 degrees, and 53 degrees; the least to 33 degrees, 43 degrees.

Table CIX (on page 158) shows:

1. That at the age of 2 to 4 days, 90 per cent of the infants reacted to the temperature stimuli.

2. That there were 100 per cent reactions to the temperature of 8 degrees.

3. That there were fewest reactions and the least activity to 43 degrees and 48 degrees.

TABLE CIX
TEMPERATURE
RELATION BETWEEN:
REACTIONS; SEPARATE STIMULI; ALL CONDITIONS;
AGE GROUPS 2-4 DAYS
Number of Infants—24

Stimulus	S	R		Sp. M.	
		f	%	f	Av.
8	48	48	100	147	3.06
13	44	41	93	124	2.82
18	44	41	93	105	2.39
23	45	42	93	96	2.13
33	46	39	85	70	1.52
43	46	35	76	55	1.20
48	48	36	75	59	1.23
53	43	88	88	79	1.84
Total	364	320		735	
% or Av.			90		2.02

Legend: Same as Table CVIII.

TABLE CX
TEMPERATURE
RELATION BETWEEN:
REACTIONS; SEPARATE STIMULI; ALL CONDITIONS;
AGE GROUP 5-7 DAYS
Number of Infants—30

Stimulus	S	R		Sp. M.	
		f	%	f	Av.
8	51	51	100	146	2.86
13	51	48	94	129	2.53
18	47	44	94	117	2.49
23	55	48	87	93	1.69
33	52	39	75	75	1.44
43	50	34	68	78	1.56
48	59	47	84	60	1.02
53	46	40	87	86	1.87
Total	411	351		784	
% or Av.			85		1.91

Legend: Same as for Table CVIII.

Table CX shows:

1. That for the age group 5 to 7 days there were 85 per cent reactions.
2. That the least number of reactions were to 43 degrees, 68 per cent.
3. That at 48 degrees the average specific movements were least, 1.02 per stimulation.

TABLE CXI
TEMPERATURE
RELATION BETWEEN:
REACTIONS; SEPARATE STIMULI; ALL CONDITIONS;
AGE GROUP 8-10 DAYS
Number of Infants—26

Stimulus	S	R		Sp. M.	
		f	%	f	Av.
8	39	37	95	113	2.90
13	43	41	95	124	2.88
18	43	40	93	124	2.88
23	42	41	97	102	2.49
33	42	36	86	68	1.62
43	40	21	53	39	.98
48	47	34	72	48	1.02
53	36	29	81	58	1.61
Total	332	279		676	
% or Av.			84		2.04

Legend: Same as for Table CVIII.

Table CXI shows:

1. That for the age group 8-10 days there were 84 per cent reactions.
2. That the lowest average of specific movements .98, is to the temperature of 43 degrees.

TABLE CXII
TEMPERATURE
RELATION BETWEEN:
REACTIONS; SEPARATE STIMULI; ALL CONDITIONS;
AGE GROUP 11 DAYS AND OLDER
Number of Infants—10

Stimulus	S	R		Sp. M.	
		f	%	f	Av.
8	23	23	100	83	3.61
13	24	24	100	81	3.38
18	24	22	92	65	2.71
23	26	24	92	67	2.68
33	25	21	84	48	1.92
43	22	16	75	35	1.59
48	21	18	86	37	1.76
53	22	16	75	34	1.55
Total	187	164		450	
% or Av.			88		2.41

Legend: Same as for Table CVIII.

Table CXII shows:

1. That for the age group 11 days and older there were 88 per cent reactions.

2. That the most pronounced reactions were to the colder temperatures, 8 degrees, 13 degrees, 18 degrees, and 23 degrees.

TABLE CXIII
TEMPERATURE
RELATION BETWEEN:
REACTIONS; ALL STIMULI; ALL CONDITIONS;
SEPARATE AGE GROUPS
Number of Infants—30

Age	S	R		Sp. M.	
		f	%	f	Av.
B-1 d	142	136	96	324	2.28
2-4 d	364	320	90	735	2.02
5-7 d	411	351	85	784	1.91
8-10 d	332	279	84	676	2.04
11 d	187	164	88	450	2.41
Total	1436	1250		2969	
% or Av.			87		2.07

Legend: Same as for Table CVIII.

Table CXIII shows:

1. That there were 87 per cent reactions for all ages.
2. That at the age level B-1 day there were 96 per cent reactions. The number of specific movements 2.41 per stimulation, is largest at the age level 11 days and older.

TABLE CXIV
TEMPERATURE
RELATION BETWEEN:
SPECIFIC MOVEMENTS; SEPARATE STIMULI; ALL CONDITIONS;
SEPARATE AGE GROUPS
Number of Infants—30

Stimulus	B-1 d		2-4 d		5-7 d		8-10 d		11 d	
	f	Av.	f	Av.	f	Av.	f	Av.	f	Av.
8	59	3.47	147	3.06	146	2.86	113	2.90	83	3.61
13	54	2.84	124	2.82	129	2.53	124	2.88	81	3.38
18	54	3.00	105	2.39	117	2.49	124	2.88	65	2.71
23	36	2.25	96	2.13	93	1.69	102	2.49	67	2.58
33	22	1.29	70	1.52	75	1.44	68	1.62	43	1.92
43	26	1.30	55	1.20	78	1.56	39	.98	35	1.59
48	39	1.95	59	1.23	60	1.02	48	1.02	37	1.76
53	34	2.27	79	1.84	86	1.87	58	1.61	34	1.55
Av.		2.28		2.02		1.91		2.04		2.41

Legend:

Stim., temperatures in degrees centigrade.

The specific movements are given in Table I. Av., average number of specific movements per stimulation as taken from Tables CVIII to CXII.

Table CXIV shows:

1. That there is a gradual decrease in the number of specific movements to temperature stimuli, beginning with birth and reaching its lowest point at the age level 5-7 days, then rising again gradually until the age level 11 days and older.

2. That the least amount of specific movement is between 33 degrees and 48 degrees.

The Tables CXV to CXXIII give the results from the infants that were asleep and dry. This is the largest group, but this does not imply that this is the most frequent condition. Because a crying baby is not a good subject, the experimenter does not select it under ordinary conditions. The asleep-and-dry group gives the most uniform reactions, and for this reason they may be regarded as a normal group. However, such other combinations as awake and dry, awake and wet, asleep and dry, crying, and the like, occur so frequently that they must be regarded as part of the normal conditions under which infants develop. It is important that 24-hour studies be made which will give the relative durations of the various conditions mentioned. Of course a 24-hour per day study for two weeks carried out in the experimental cabinet represents a limit toward which we can only approach. It will not be possible to observe large numbers, but even a few carefully planned observations throughout the diurnal period will be well worth while.

TABLE CXV
TEMPERATURE
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; ALL STIMULI; CONDITIONS
ASLEEP AND DRY; SEPARATE AGE GROUPS
Number of Infants—30

Age	Hd.	Fa.	Bo.	Ex.	So.	Ey.	M.	Su.
	%	%	%	%	%	%	%	%
B-1 d	9	12	17	20	4	0	8	30
2-4 d	14	10	19	20	5	1	6	25
5-7 d	17	13	18	15	5	3	7	22
8-10 d	11	12	20	19	6	4	8	20
11 d	10	16	23	20	3	3	9	16
Av. %	13	12	19	19	4	2	8	23

Legend:

Age, the age groupings in days.

Specific movement groups are head movements, facial, body, extremities, sounds, eye movements, mouth movements (sucking excluded), and sucking.

%, the centiles for each movement group.

Table CXV shows:

1. That the most frequent reaction is sucking, 23 per cent.
2. That the sucking reactions are most pronounced at B-1 day, 30 per cent, and decrease gradually with age to 16 per cent.

TABLE CXVI
TEMPERATURE
RELATION BETWEEN:
SPECIFIC MOVEMENTS; SEPARATE STIMULI; CONDITION
ASLEEP AND DRY; SEPARATE AGE GROUPS
Number of Infants—30

Stimulus	B-1 d	2-4 d	5-7 d	8-10 d	11 d
	Av.	Av.	Av.	Av.	Av.
8.....	3.50	2.92	2.56	2.85	3.88
13.....	3.44	2.65	2.78	3.53	3.56
18.....	3.00	2.34	2.37	2.81	2.56
23.....	2.25	2.00	1.87	2.53	2.50
33.....	1.81	1.42	.96	1.58	1.94
43.....	1.28	1.14	1.19	1.03	1.50
48.....	1.95	1.21	1.04	1.24	1.62
53.....	2.27	1.80	1.80	1.88	1.69
Av.	2.37	1.93	1.81	2.19	2.43

Legend:

Stim., temperatures in degrees centigrade.

Av., average number of movements per stimulation for corresponding headings.

Table CXVI shows:

1. That there is a minimum of reaction to temperature at the age 5-7 days.
2. That the reactions are least for the temperature 43 degrees and greatest for the lowest temperature, 8 degrees.

TABLE CXVII
TEMPERATURE
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; SEPARATE STIMULI;
CONDITIONS ASLEEP AND DRY; ALL AGES
Number of Infants—30

Sp. M. Groups	8	13	18	23	33	43	48	53
	%	%	%	%	%	%	%	%
Head	21	22	19	15	4	5	3	11
Face	23	21	17	15	7	2	6	9
Body	23	19	14	14	10	5	7	8
Extrem.	18	22	16	11	6	7	8	12
Sounds	26	22	13	13	9	4	4	9
Eye M.	14	19	17	2	6	16	10	16
Sucking	10	14	13	14	4	13	12	10
Mouth	13	16	19	16	5	8	12	11
Av. %	18	18	16	14	9	7	8	10

Legend for Table CXVII:

Sp. M. Groups, specific movement groups of the muscles of the head, face, body, extremities, sounds produced, eye movements, sucking, mouth movements.

%, centiles for the corresponding headings. (These add 100 horizontally.)

8°C., 13°C., 18°C., etc.

Table CXVII shows:

1. That of the specific reactions to temperature, the reactions to cold, 8, 13, 18, 23, made up 66 per cent of the reactions.
2. The least reaction 7 per cent, was to 43 degrees.
3. That the infants reacted less strongly to the temperatures which are warmer than body temperature than to those which are colder. (Body temperature is assumed to be 37 degrees, but we did not determine this value for infants.)

TABLE CXVIII
TEMPERATURE
RELATION BETWEEN:
REACTIONS; SEPARATE STIMULI; CONDITION ASLEEP
AND DRY; AGE GROUP BIRTH TO 1 DAY
Number of Infants—14

Temp.	S	R		Sp. M.	
	N	f	%	f	Av.
8	16	16	100	56	3.50
13	18	18	100	62	3.44
18	17	17	100	51	3.00
23	16	16	100	36	2.25
33	16	14	88	21	1.31
43	18	16	89	23	1.28
48	19	19	100	37	1.95
53	15	13	87	34	2.27
Total	135	129		320	
% or Av.			96		2.37

Legend:

S, N, number of stimulations.

R, reactions per stimulation. One reaction may include a number of specific movements. f, %, number and centiles of reactions.

Sp. M., specific movements as shown in Table I. f, av., number and average number of movements per stimulation.

Total, %, av., total, centiles or averages of corresponding headings.

Table CXVIII shows:

1. That the infants several hours to one day old reacted to 96 per cent of the temperature stimulations.
2. That the smallest percentage of reactions, 88 per cent, was to the temperature 33 degrees, while the smallest average of specific movements, 1.28, was to 43 degrees.
3. That there were 100 per cent reactions to 8 degrees, 13 degrees, 18 degrees, 23 degrees, and 48 degrees.

TABLE CXIX
TEMPERATURE
RELATION BETWEEN:
REACTIONS; SEPARATE STIMULI; CONDITION ASLEEP
AND DRY; AGE GROUP 2 TO 4 DAYS
Number of Infants—21

Temp.	S	R		Sp. M.	
	N	f	%	f	Av.
8	38	38	100	111	2.92
13	34	32	94	90	2.65
18	35	33	94	82	2.34
23	36	34	94	72	2.00
33	36	30	83	51	1.42
43	37	28	76	42	1.14
48	38	28	74	46	1.21
53	35	30	86	63	1.80
Total	289	253		557	
% or Av.			87		1.93

Legend: Same as for Table CXVIII.

Table CXIX shows:

1. That at this age level reactions occurred to 87 per cent of the temperature stimulations.
2. That the smallest average of specific movements was to 43 degrees.

TABLE CXX
TEMPERATURE
RELATION BETWEEN:
REACTIONS; SEPARATE STIMULI; CONDITION ASLEEP
AND DRY; AGE GROUP 5-7 DAYS
Number of Infants—21

Temp.	S	R		Sp. M.	
	N	f	%	f	Av.
8	27	27	100	69	2.56
13	27	26	96	75	2.78
18	27	25	93	64	2.37
23	31	24	77	58	1.87
33	29	19	65	28	.96
43	26	17	65	31	1.19
48	27	20	74	28	1.04
53	25	22	88	45	1.80
Total	219	180		397	
% or Av.			82		1.81

Legend: Same as for Table CXVIII.

Table CXX shows:

1. That at the age 5-7 days the largest percentage of reaction

was to 8 degrees, 13 degrees, 18 degrees, and 53 degrees, and the smallest to 33 degrees and 43 degrees.

2. Of the specific movements, the smallest averages are to 33 degrees, 43 degrees, and 48 degrees.

TABLE CXXI
TEMPERATURE
RELATION BETWEEN:
REACTIONS; SEPARATE STIMULI; CONDITION ASLEEP
AND DRY; AGE GROUP 8-10 DAYS
Number of Infants—23

Temp.	S	R		Sp. M.	
	N	f	%	f	Av.
8	27	26	96	77	2.85
13	30	28	90	106	3.53
18	32	29	91	90	2.81
23	30	29	97	76	2.53
33	31	25	81	49	1.58
43	30	16	53	31	1.03
48	29	20	70	36	1.24
53	25	20	80	47	1.88
Total	234	193		512	
% or Av.			82		2.19

Legend: Same as for Table CXVIII.

Table CXXI shows:

1. That at this age the largest percentage of reactions was to 8 degrees, the smallest to 43 degrees.

2. The number of specific movements is smallest for 43 degrees.

TABLE CXXII
TEMPERATURE
RELATION BETWEEN:
REACTIONS; SEPARATE STIMULI; CONDITION ASLEEP
AND DRY; AGE GROUP 11 DAYS AND OLDER
Number of Infants—9

Temp.	S	R		Sp. M.	
	N	f	%	f	Av.
8	17	17	100	66	3.88
13	18	18	100	64	3.56
18	18	16	90	46	2.56
23	18	16	90	45	2.50
33	18	15	83	35	1.94
43	16	11	69	24	1.50
48	16	13	81	26	1.62
53	16	12	75	27	1.69
Total	137	118		333	
% or Av.			86		2.43

Legend: Same as for Table CXVIII.

Table CXXII shows:

1. That at this age level there were 86 per cent reactions to all stimuli.
2. That there were only 69 per cent reactions at 43 degrees.
3. That the average of specific movements is least for 43 degrees and 48 degrees.

TABLE CXXIII
TEMPERATURE
RELATION BETWEEN:
REACTIONS; ALL STIMULI; CONDITIONS ASLEEP AND DRY;
SEPARATE AGE GROUPS
Number of Infants—30

Age Group	S	R		Sp. M.	
	N	f	%	f	Av.
B-1 d	135	129	96	320	2.37
2-4 d	289	253	87	557	1.93
5-7 d	219	180	82	397	1.81
8-10 d	234	193	82	512	2.19
11 d	137	118	86	333	2.43
Total	1014	873	86	2119	2.09
% or Av.					

Legend:

S, N, number of stimulations.

R, reactions per stimulation. One reaction may include a number of specific movements. f, %, number and centiles of reactions.

Sp. M., specific movements as shown in Table I. f, av., number and average number of movements per stimulation.

Total, %, av., total, centiles or averages of corresponding headings.

Table CXXIII shows:

1. That there were 86 per cent reactions to all temperature stimuli.
2. That for the age group birth to 1 day, there was the largest percentage of reaction, 96 per cent, but the largest average of specific movements, 2.43, is recorded for 11 days and older. This may be an indication that motor coördination is already beginning to show itself at this age.

SUMMARY

A. For the whole group (all physiological conditions combined).

1. To 30 infants there were given 222 tests, and 1,436 stimulations of temperatures at the following: 8 degrees C., 13 degrees

C., 18 degrees C., 23 degrees C., 33 degrees C., 43 degrees C., 48 degrees C., and 53 degrees C.

2. The physiological conditions of the infants were as follows: 68 per cent asleep and dry; 24 per cent asleep and wet; 5 per cent awake and dry; 3 per cent awake and wet (Table CVII).

3. The infants reacted to 87 per cent of the stimulations (Table CXIII).

4. For the age group, birth-1 day, there were 96 per cent reactions; for 2-4 days, 90 per cent; for 5-7 days, 85 per cent; for 8-10 days, 84 per cent; for 11 days and older, 88 per cent (Table CXIII).

5. The number of specific movements per stimulation is largest for the age group 11 days and older, 2.41, and smallest at 5-7 days, 1.91 (Table CXIV).

B. For the group "Asleep and Dry."

6. Of the activities recorded as specific movement groups 23 per cent are sucking reactions; 19 per cent are movements of the extremities; 19 per cent are general body movements; 13 per cent head movements; 12 per cent facial movements; 8 per cent mouth movements, exclusive of sucking; 4 per cent mouth sounds; 2 per cent eye movements (Table CXV).

7. The sucking reactions are most pronounced for the age group, birth-1 day, 30 per cent, and decrease gradually to 11 days and older, 16 per cent (Table CXV).

8. The percentage of body reactions increases from birth, 17 per cent, to the highest age level given, 23 per cent. Other specific reactions vary only slightly from birth to 11 days and older (Table CXV).

9. Of the specific movement groups, 18 per cent are to 8 degrees; 18 per cent to 13 degrees; 16 per cent to 18 degrees; 14 per cent to 23 degrees; 9 per cent to 33 degrees; 7 per cent to 43 degrees; 8 per cent to 48 degrees; and 10 per cent to 53 degrees (Table CXVII).

10. The infants reacted less strongly to the temperatures which are warmer than body temperature than to those which are colder. (Skin temperature is assumed to be about 37 degrees for adults, but we did not determine this value for infants.)

CHAPTER VIII

REACTIONS TO HOLDING THE NOSE AND HOLDING THE ARMS

HISTORICAL

These two forms of stimulation have been used in some rather recent investigations and are said by some authors to release "defense reactions." Watson (1919) reports four cases in which "early defense movements have been rather thoroughly tried out on a large number of infants, but by a very crude method. The nose is lightly pinched and the length of time it takes the child to touch the experimenter's fingers is recorded" (p. 242). He then cites four cases of infants at the following ages: 3 days, 4 days, 8 days, and 12 days. In each case he reports that the infant's hands struck the experimenter's fingers, the time at which this followed upon stimulation varying from two to four seconds.

The reactions to holding the arms to the sides of the infant are described by Watson as rage reactions. "Almost any child from birth can be thrown into a rage if its arms are held tightly to the sides; sometimes even if the elbow joint is clasped tightly between the fingers the response appears; at times just the placing of the head between cotton pads will produce it" (p. 200). These rage reactions are described by him as "a stiffening of the body and fairly well coördinated slashing or striking movements of the hands and arms; the feet and legs are drawn up and down; the breath is held until the child's face is flushed" . . . "These reactions continue until the irritating situation is relieved, and sometimes do not cease then" (p. 200).

The Shermans (1925) investigated the coördination of the arms in a defense reflex to pressure upon the chin. No infant under 21 hours made a successful defense movement. "The stimulus was applied only when the subject was quiet, the number of arm movements necessary for a perfect coördination was then counted. A coördinated movement was considered as one in which both of the infant's hands touched the distal part of the experimenter's

fingers, that is, at the chin, in a pushing motion" (p. 67). They found a negative correlation of .45 between number of movements and age.

HOLDING THE NOSE

METHOD

The form of stimulation which was used in this investigation was that of exerting a gentle pressure on the infant's nose, by holding it between the thumb and index finger in such a way as to close off the nostrils. In the earlier investigations the time of stimulation was between 4.5 and 6 seconds. In the later investigations this was in some cases extended to 10 seconds and occasionally to 15 seconds. In no case was the stimulation continued if the infant cried out. If no reaction occurred with a 10- to 15-second time limit, the stimulation was discontinued.

PRELIMINARY EXPERIMENTS

In a preliminary experiment with 21 infants, only the movements "Reaction" or "No Reaction" were reported. The results are shown in Table CXXIV for the conditions of asleep and awake. The term "asleep" means that the infants' eyes were closed and body inactive when the experiment started. After the stimulus was applied for a few seconds, most of the infants awoke, although some of them made very few movements.

The approximate time of the stimulation was from 4 seconds to 6 seconds. If the experimenter observed no change in either the infant's state of activity or in his lack of activity, he recorded "no reaction." If a change followed upon stimulation, this was so recorded.

Table CXXIV on the following page (170) shows:

1. That to holding the nose when infants are asleep there were 76 per cent reactions, which leaves 24 per cent, or nearly one-fourth, of the stimulations without reactions. In no case were there any violent movements or crying.
2. That the reactions were fewer when infants were asleep, 76 per cent, than when awake, 86 per cent.

TABLE CXXIV
Holding Nose
RELATION BETWEEN:
REACTIONS; CONDITIONS, ASLEEP AND AWAKE;
SEPARATE AGE GROUPS
Number of Infants—21

Days Age	S N	Asleep		Awake	
		f	%	f	%
0	9	4	100	4	80
1	13	6	66	4	100
2	7	2	67	4	100
3	14	8	89	5	100
4	12	8	89	2	67
5	8	4	57	1	100
6	9	7	78	0	0
7	12	5	71	4	80
8	11	4	57	4	100
9	10	5	71	3	100
10	8	5	83	1	50
11	8	3	75	3	75
12	5	2	67	1	50
13	3	2	100	1	100
14	1	.....	.....	1	100
17	2	.....	.....	2	100
Total	132	65	76	40	86
Av. %					

Legend:

S, N, number of stimulations, both conditions.

R, reactions. Some form of movement to the stimulating condition.

%, centiles of reactions for the corresponding ages.

Total, av, %, total and average centiles for the corresponding headings.

See preceding page for summary of table and explanation of terms "asleep" and "awake."

FINAL EXPERIMENTS

In the final investigations which follow, the symbols in Table I were revised as shown in Table CXXV.

It is difficult to prepare a list of symbols which are not ambiguous under rapid recording. Usually this is not significant because the context will furnish the key to the reaction which was meant to be recorded. There is an almost automatic tendency toward the simplification of symbols and this may end in assigning the same symbols for different reactions. Where separate reactions are classified this may become serious, but where many movements are grouped together under one larger category (as in all these experiments) the "doubling up" is not so serious, or is "caught" before it becomes serious.

TABLE CXXV

DESCRIPTION OF SPECIFIC MOVEMENTS RECORDED BY EXPERIMENTER
IN RESPONSE TO HOLDING THE NOSE

HEAD	EYES
Hd1—head rolling	E1—eyes opened
Hd2—head drawn back	E2—eyes closed
Hd3—head drawn forward	E3—tightening lids, blinking
MOUTH	SOUNDS
M1—mouth opened	S1—crying
M2—mouth closed	S2—coughing
M3—pursing lips	S3—sneezing
M4—smacking lips	S4—yawning
M5—licking lips	S5—regurgitating
M6—expelled water	S6—vocalizing
M7—tongue protruded	S7—choking sounds
M8—mouth breathing	S8—hiccoughing
FACE	S9—swallowing
F1—wry face	S10—throat sounds
F2—frown or wrinkling face	S11—whimpering
F3—grimace	S—sucking
F4—reddening of face	
BODY	"DEFENSE"
B1—rolling	Hn—hands to nose
B2—squirming	HE—striking experimenter's hands
B3—stretching	
B4—rapid breathing	EXTREMITIES
B5—general activity	L—legs 1—extension
B6—jerk	A—arms 2—flexion
B7—shudder	H—hands 3—slashing
B8—gasp or quick intake	T—toes 4—kicking
B9—organic disturbance	Ft—feet 5—to mouth
B10—back arched	Fg—fingers 6—over head
B11—wriggling	Hp—hips 7—over face
B12—struggling	8—rubbing
	9—fanning
	10—trembling
	11—jerked
	12—raised
	X—crossed

TABLES, DATA, RESULTS

TABLE CXXVI
HOLDING NOSE
SEX AND RACE DISTRIBUTION

	White	Black	Total
Female	21	16	37
Male	14	16	30
Total	35	32	67

TABLE CXXVII
HOLDING NOSE
RELATION BETWEEN:
SEPARATE CONDITIONS; SEPARATE AGES
Number of infants—67

Age Days	S N	As. Dr.		As. W.		Aw. Dr.		Aw. W.	
		f	%	f	%	f	%	f	%
0	14	11	84	1	2	2	14	0	0
1	20	19	95	0	0	1	5	0	0
2	30	20	67	4	13	4	13	2	7
3	29	22	76	4	14	1	3	2	7
4	32	26	81	4	13	2	6	0	0
5	33	15	46	11	33	1	3	6	18
6	34	22	65	11	32	0	0	1	3
7	34	13	40	17	50	2	5	2	5
8	31	18	58	10	32	1	3	2	7
9	38	21	55	12	32	1	2	4	11
10	34	14	41	10	29	3	9	7	21
11	22	11	50	7	32	3	14	1	4
12	16	8	50	6	38	2	12	0	0
13	8	5	63	3	37	0	0	0	0
14	10	7	70	1	10	0	0	2	20
15	2	1	50	0	0	0	0	1	50
21	1	1	100	0	0	0	0	0	0
Total	388	234		101		23		30	
Per cent ...			60		26		6		8

Legend:

S, N, number of tests for all conditions.

As, Aw, W, Dr, asleep, awake, wet, dry. f, %, number and centiles for the corresponding ages.

Total, %, total and centiles for corresponding conditions.

TABLE CXXVIII
HOLDING NOSE
RELATION BETWEEN:
REACTIONS; SPECIFIC MOVEMENTS; ALL CONDITIONS;
SEPARATE AGE GROUPS
Number of infants—67

Age Days	S N	R		Sp. M.	
		f	%	f	Av.
B-1 d.....	34	33	97	105	3.09
2-4 d.....	92	86	93	249	2.71
5-7 d.....	101	96	95	254	2.51
8-10 d.....	103	97	94	259	2.51
11 d.....	58	56	97	136	2.34
Total	388	368		1003	
% or Av. ...			96		2.58

Legend:

S, N, number of stimulations.

R, reaction. A reaction may include a number of specific movements.

f, %, number and centiles of reactions per stimulation.

Sp. M., specific movements as listed in Table CXXV. f, av., number and average number of specific movements per stimulation.

Total, %, av., totals, centiles and averages for the corresponding headings.

Table CXXVIII shows:

1. That the number of specific movements per stimulation decreases with age from 3.09 to 2.34.

2. That the average number of reactions per stimulation is high 96 per cent.

TABLE CXXIX
HOLDING NOSE
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; CONDITIONS ASLEEP AND DRY;
SEPARATE AGE GROUPS
Number of infants—64

Age Days	S N	Hd. Bk.		Bk. ach.		Body		Extrem.		Hnds.		Other	
		f	%	f	%	f	%	f	%	f	%	f	%
B-1 d	30	22	23	11	12	8	8	41	43	0	0	13	14
2-4 d	68	37	20	21	12	34	19	54	30	3	1	33	18
5-7 d	51	33	23	18	13	22	16	47	33	1	1	20	14
8-10 d	53	27	20	13	10	26	20	39	30	4	3	22	17
11 d	32	15	21	7	10	16	22	16	22	2	3	16	22
Total	234	134		70		106		197		10		104	
Per cent			22		11		17		32		1		17

Legend:

S, N, number of stimulations.

Hd. bk., head drawn back.

Bk. ach., arching spine.

Body, general body movements.

Extrem., movements of the extremities.

Hnds., hands striking experimenter and hands to infant's nose. This is the so-called defense reaction.

Oth., all other movements.

A more complete list of these specific movements is given in Table CXXV.

f, %, number and centiles for corresponding age groups.

T, %, totals and average centiles for corresponding headings.

Table CXXIX shows:

1. That in the asleep-and-dry group, the most frequent reactions to holding the nose are: drawing back head 22 per cent; arching of the spine 11 per cent; movements of the extremities 32 per cent. These three groups of movements constitute 65 per cent of all the reactions.

2. The movements "Hnds," the so-called defense reactions, constitute only 1 per cent of all the movements and cannot therefore be said to be the typical reactions to holding the nose. They show a slight increase with age from 0 to 3 per cent.

TABLE CXXX
HOLDING NOSE
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; CONDITIONS, ASLEEP AND WET;
SEPARATE AGE GROUPS
Number of infants—61

Age Days	S N	Hd. Bk.		Bk. ach.		Body		Extrem.		Hnds.		Other	
		f	%	f	%	f	%	f	%	f	%	f	%
B-1 d	1	1	25	1	25	0	0	2	50	0	0	0	0
2-4 d	13	5	14	5	14	5	14	11	32	0	0	9	26
5-7 d	38	19	20	7	8	23	25	26	27	1	1	17	19
8-10 d	32	18	22	4	5	13	15	31	39	1	1	15	18
11 d	17	6	14	3	7	11	26	15	36	0	0	7	17
Total	101	49		20		52		85		2		48	
Per cent			19		8		20		33		1		19

Legend: Same as for Table CXXIX.

Table CXXX shows:

1. That for the condition "asleep and wet," only 1 per cent were "defense" movements.
2. That arching of the back, drawing backward of the head, and movements of the extremities constitute 60 per cent of all the reactions.

TABLE CXXXI
HOLDING NOSE
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; CONDITIONS, AWAKE AND DRY;
SEPARATE AGE GROUPS
Number of infants—16

Age Days	S N	Hd. Bk.		Bk. ach.		Body		Extrem.		Hnds.		Other	
		f	%	f	%	f	%	f	%	f	%	f	%
B-1 d	3	1	17	1	17	1	16	0	0	0	0	3	50
2-4 d	7	4	20	3	15	2	10	6	30	0	0	5	25
5-7 d	3	1	100	0	0	0	0	0	0	0	0	0	0
8-10 d	5	2	17	0	0	4	33	3	25	0	0	3	25
11 d	5	3	25	1	8	1	8	4	34	0	0	3	25
Total	23	11		5		8		13		0		14	
Per cent			22		10		16		25		0		27

Legend: Same as for Table CXXIX.

Table CXXXI shows:

1. That there were in this group no "defense reactions."
2. That the most frequent reactions are the drawing backward of the head 22 per cent; arching of the back 10 per cent; general body movements 16 per cent; and movements of the extremities 25 per cent.

TABLE CXXXII
HOLDING NOSE
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; CONDITIONS, AWAKE AND WET;
SEPARATE AGE GROUPS
Number of infants—27

Age Days	S N	Hd. Bk.		Bk. ach.		Body		Extrem.		Hnds.		Other	
		f	%	f	%	f	%	f	%	f	%	f	%
B-1 d	0	0	0	0	0	0	0	0	0	0	0	0	0
2-4 d	4	1	8	0	0	2	17	2	17	0	0	7	58
5-7 d	9	5	26	3	16	5	26	2	11	0	0	4	21
8-10 d	13	9	26	5	15	3	9	9	26	0	0	8	24
11 d	4	2	20	1	10	2	20	2	20	0	0	3	30
Total	30	17		9		12		15		0		22	
Per cent			23		12		16		20		0		29

Legend: Same as for Table CXXIX.

Table CXXXII shows:

1. That striking the experimenter's hands or bringing the hands to the nose did not occur once to the 30 stimulations given to this "awake-and-wet" group.

2. That drawing backward of the head constitutes 23 per cent of all the reactions; arching of the back 12 per cent; general body movements 16 per cent; movements of extremities 20 per cent; and all other movements together 29 per cent.

TABLE CXXXIII
HOLDING NOSE
RELATION BETWEEN:
SPECIFIC MOVEMENT GROUPS; SEPARATE CONDITIONS;
ALL AGE GROUPS
Number of infants—67

Cond.	S N	Hd. Bk.		Bk. ach.		Body		Extrem.		Hnds.		Other	
		f	%	f	%	f	%	f	%	f	%	f	%
As. Dr. . . .	234	134	22	70	11	106	17	197	32	10	1	104	17
As. W. . . .	101	49	19	20	8	52	20	85	33	2	1	48	19
Aw. Dr. . . .	23	11	22	5	10	8	16	13	25	0	0	14	27
Aw. W. . . .	30	17	23	9	12	12	16	15	20	0	0	22	29
Total	388	211		104		178		310		12		188	
Per cent			21		10		18		31		1		19

Legend:

Cond., As., Aw., W., Dr., asleep, awake, wet, dry.

S, N, number of stimulations.

Hd. bk., etc., the specific movement groups given in legend of Table CXXIX.

Table CXXXIII shows:

1. That to 388 stimulations there were 1,003 specific movements, of which 21 per cent were drawing backward of the head; 10 per cent were arching of the back; 18 per cent were general body movements; 31 per cent were movements of the extremities; other movements 19 per cent.
2. That only 1 per cent were of the type of movements which could be described as "defense reactions" such as movements of the hands to the nose or striking the experimenter's hands.

SUMMARY

HOLDING THE NOSE

1. This form of stimulation, applied 388 times to 67 infants, produced 96 per cent reactions (Table CXXVIII). In the preliminary experiments there were 86 per cent reactions to "awake"; 76 per cent to "asleep" (Table CXXIV).
2. The number of specific movements per stimulation was largest for the age level B-1 day, 3.09, and decreased gradually to 11 days and older, 2.34 (Table CXXVIII).
3. Of the specific movement groups 22 per cent were drawing backward of the head; 11 per cent were arching of the back; 17 per cent were general body movements; 32 per cent were movements of the extremities; all other movements constituted 18 per cent (Table CXXIX).
4. Of the total number of specific movements, only 1 per cent were those movements of the hands to the nose, or striking the experimenter's hands which have been described as "defense reactions" (Table CXXXIII).

The results of this experiment show that the typical reactions to the stimulation of lightly pinching the nose of an infant are: a drawing backward of the head, arching of the back, general restlessness, and non-specific body movements. We cannot substantiate Watson's contention that defense reactions are the typical reactions to this form of stimulation. Even if it were justifiable to consider the bringing of the hand to the nose, or its coming in contact with the experimenter's hands a defense reaction, these two reactions

constituted only 1 per cent of all those reported. Watson reports only 4 cases in which defense reactions were observed, but suggests that these are typical reactions to pinching of the nose of an infant. Our conclusions are based on the results of 388 tests, and show that the form of reaction which Watson calls defense is certainly not the typical reaction to this form of stimulation for infants less than two weeks old. The length of time that the nose was held varied from 5 to 15 seconds, most of the cases being longer than ten seconds.

HOLDING THE ARMS

The next series of tables gives the results of another form of "hampering movements."

The form of stimulation consisted in pressing the arms firmly against the body and holding them there against whatever energy the infant would exert. We replaced our regular list of specific reactions by a more kinetic description of the movements. These descriptions were then grouped into the four classes: Active; Passive; Active-passive; Passive-active.

TABLE CXXXIV
DESCRIPTION OF REACTIONS RECORDED IN RESPONSE
TO HOLDING THE ARMS

ACTIVE (A)

Under this grouping come such reports as the following:

- Arms did not remain at sides of body
- Arms immediately flexed again to original posture
- Kicking of legs, arms flexed again to original posture
- Struggled and cried, arms raised again to original posture
- Rapid breathing, wriggling
- Squirming, wriggling

PASSIVE (P)

This includes such reports as the following:

- No response
- Arms remain at side of body

ACTIVE-PASSIVE (AP)

A period of activity followed immediately upon stimulation, but was then followed by inactivity. The stimulation had a quieting effect. Some of the typical reports which fall in this group are the following:

- Quieted
- Squirming, then quiet
- Struggle, then remained in position
- Head rolling, then quiet
- Jerk, rapid breathing, arms relaxed
- Stretching, then arms remained at side of body
- Head rolling, legs flexed, then arms remained as placed by experimenter.

PASSIVE-ACTIVE (PA)

In this group are classed all those cases in which a quieting effect is immediately followed by a period of activity. This includes reports such as the following:

In position short time, then flexed

Struggle, arms in position short time, then flexed

Head rolling, squirming, quieted; arms did not remain at the sides of the body.

Eyes opened, quieted, then legs kicking

Tables CXXXVI to CXL give the results of the observations classified under the categories of Table CXXXIV.

TABLES, DATA, RESULTS

TABLE CXXXV

HOLDING ARMS

RELATION BETWEEN:

SEPARATE CONDITIONS; SEPARATE AGES

Number of infants—66

Age Days	S N	As. Dr.		As. W.		Aw. Dr.		Aw. W.	
		f	%	f	%	f	%	f	%
0	12	10	84	1	8	1	8	0	0
1	19	17	90	1	5	1	5	0	0
2	26	17	65	4	15	3	12	2	8
3	26	19	73	4	15	1	4	2	8
4	28	24	86	3	11	1	3	0	0
5	33	15	46	11	33	1	3	6	18
6	33	22	69	10	30	0	0	1	1
7	33	14	42	15	46	2	6	2	6
8	28	16	57	9	32	1	4	2	7
9	33	17	52	11	33	1	3	4	12
10	32	13	41	10	31	3	9	6	19
11	21	9	43	8	38	3	14	1	5
12	15	8	53	5	33	2	14	0	0
13	8	5	63	3	37	0	0	0	0
14	8	5	63	1	12	0	0	2	25
15	2	1	50	0	0	0	0	1	50
21	1	1	100	0	0	0	0	0	0
Total	358	213	59	96	27	20	6	29	8
Per cent ...									

Legend:

N, number of tests for all conditions.

As, Aw, W, Dr., asleep, awake, wet, dry. f, %, number and centiles for the corresponding ages.

Table CXXXV shows:

1. That in 59 per cent of these tests of holding arms the infants were asleep and dry; in 27 per cent they were asleep and wet; in 6 per cent they were awake and dry; and in 8 per cent they were awake and wet.

TABLE CXXXVI

RELATION BETWEEN: VARIATIONS IN ACTIVITY
CONDITIONS, ASLEEP AND DRY; SEPARATE AGE GROUPS
Number of infants—63

Age	S N	A		P		AP		PA	
		f	%	f	%	f	%	f	%
B-1 d	27	8	29	11	41	7	26	1	4
2-4 d	60	7	12	34	57	17	28	2	3
5-7 d	50	8	16	25	50	16	32	1	2
8-10 d	46	5	11	35	76	6	13	0	0
11 d	30	2	7	21	70	6	20	1	3
Total	213	30		126		52		5	
Per cent ...			14		59		25		2

Legend:

S, N, number of stimulations.

A, active; P, passive; AP, active-passive; PA, passive-active, as indicated in Table CXXXIV. f, %, number and centiles for corresponding ages.

Table CXXXVI shows:

1. That there were 59 per cent no reactions, the arms remaining in the position into which the experimenter put them.
2. That there were 25 per cent reactions in which there was a quieting effect, or a brief period of activity gave place to quiet.
3. That there were 14 per cent reactions in which the arms immediately flexed again, or there were other signs of activity.
4. That in only 2 per cent was there anything like a defense reaction.

TABLE CXXXVII

HOLDING ARMS
RELATION BETWEEN: VARIATIONS IN ACTIVITY
CONDITIONS, ASLEEP AND WET; SEPARATE AGE GROUPS
Number of infants—48

Age	S N	A		P		AP		PA	
		f	%	f	%	f	%	f	%
B-1 d	2	0	0	1	50	0	0	1	50
2-4 d	10	2	20	5	50	2	20	1	10
5-7 d	37	9	24	17	46	11	30	0	0
8-10 d	30	0	0	20	67	10	33	0	0
11 d	17	1	6	14	82	2	12	0	0
Total	96	12		57		25		2	
Per cent ...			13		59		26		2

Legend: Same as for Table CXXXVI.

Table CXXXVII shows:

1. That 59 per cent of the infants remained passive, that is, the arms remained in the position into which the experimenter put them.
2. That in 26 per cent the stimulation had a quieting effect.
3. That in 13 per cent the arms immediately flexed again, and that in 2 per cent the brief period of passivity was followed by one of activity.

TABLE CXXXVIII
HOLDING ARMS
RELATION BETWEEN: VARIATIONS IN ACTIVITY
CONDITIONS, AWAKE AND DRY; SEPARATE AGE GROUPS
Number of infants—19

Age	S N	A		P		AP		PA	
		f	%	f	%	f	%	f	%
B-1 d	2	0	0	2	100	0	0	0	0
2-4 d	5	3	60	1	20	1	20	0	0
5-7 d	4	1	25	3	75	0	0	0	0
8-10 d	5	0	0	3	60	2	40	0	0
11 d.....	4	0	0	2	50	2	50	0	0
Total	20	4		11		5		0	
Per cent ...			20		55		25		0

Legend: Same as for Table CXXXVI.

Table CXXXVIII shows:

1. That 80 per cent of the stimulations had either no effect, or else a quieting effect upon the infants.
2. That in 20 per cent the arms were immediately flexed again, or there were other forms of activity.

TABLE CXXXIX
HOLDING ARMS
RELATION BETWEEN: VARIATIONS IN ACTIVITY
CONDITIONS, AWAKE AND WET; SEPARATE AGE GROUPS
Number of infants—26

Age	S N	A		P		AP		PA	
		f	%	f	%	f	%	f	%
B-1 d	0	0	0	0	0	0	0	0	0
2-4 d	5	0	0	4	80	1	20	0	0
5-7 d	8	1	12	3	38	2	25	2	25
8-10 d	12	0	0	4	33	6	50	2	17
11 d.....	4	0	0	3	75	1	25	0	0
Total	29	1		14		10		4	
Per cent ...			4		48		34		14

Legend: Same as for Table CXXXVI.

Table CXXXIX shows:

1. That of the 29 stimulations, 48 per cent had no effect on the infant, while 34 per cent had a quieting effect.

2. In 4 per cent of the cases the arms were immediately flexed again.

3. In 14 per cent a brief period of quiet was followed by activity (PA). However, the awake-and-wet group is the most active group under all other conditions, and the question arises whether the "defense reaction" reported by others is not a reaction to the physiological condition of the infant, rather than to that of holding the arms.

TABLE CXL
HOLDING ARMS
RELATION BETWEEN: VARIATIONS IN ACTIVITY
ALL CONDITIONS; ALL AGE GROUPS
Number of infants—66

Cond.	S			P		AP		PA	
	N	f	%	f	%	f	%	f	%
As. Dr.	213	30	14	126	59	52	25	5	2
As. W.	96	12	13	57	59	25	26	2	2
Aw. Dr.	20	4	20	11	55	5	25	0	0
Aw. W.	29	1	4	14	48	10	34	4	14
Total	358	47		208		92		11	
Per cent ...			13		58		26		3

Legend:

Cond. As., Aw., W., Dr., asleep, awake, wet, dry.

S, N, number of stimulations.

A, P, AP, PA, active, passive, active-passive, passive-active, as described in Table CXXXIV. f, %, number and centiles for corresponding conditions.

Table CXL shows:

1. That of 358 stimulations, 58 per cent had no effect, the arms remaining in the position into which the experimenter put them.

2. That in 26 per cent the stimulation had a quieting effect, or a brief period of activity gave place to quiet.

3. That in 13 per cent the arms immediately flexed again, or there were other signs of activity; while in 3 per cent a brief period of quiet was followed by one of activity.

SUMMARY

HOLDING ARMS

1. This experiment was performed 358 times on 66 infants. To 58 per cent of these stimulations the infants remained passive, that is, the arms merely remained in the position in which the experimenter placed them; in 26 per cent a brief period of activity gave place to inactivity; in 13 per cent the arms immediately flexed again or there were other signs of activity; while in 3 per cent a brief period of quiet was followed by activity (Table CXL).

2. In the asleep-and-dry group the centiles of reactions described as "active" decreased from birth; those described as "passive" showed an increase with age.

3. The results agree with those of the Shermans in that no definite "defense" or "rage" reactions were found in any considerable number of cases.

CHAPTER IX

THE PLANTAR REACTION; THE SUCKING REACTION

THE PLANTAR REACTION

HISTORICAL

Almost without exception the contributors to the extensive and constantly growing literature upon the plantar reaction unite in ascribing its discovery and description to Babinski and in naming the response after him. Although Babinski's researches are brilliant and furnish a very significant chapter in the science of neurology, his statements concerning the clinical significance of the adult pathological plantar response do not represent the first knowledge of the existence of the phenomenon or its first mention in the literature dealing with the newborn child.

It is impossible to fix with any degree of certainty the first recorded observation of the extensor plantar reflex of the infant. Kussmaul (1859) observed that when the sole of the foot was stimulated there was flexion and extension at the knee and hip and extension of the toes. Genzmer (1873) in investigating touch sensitivity discovered the soles, palms, and nasal mucosa to be very sensitive areas, and Kroner (1882) found that the soles were more sensitive than the palms. Preyer (1881) noted that stimulation of the sole brought about a spreading of the toes—evidently the "*signe d'éventail*." He also records that Darwin had observed a quick withdrawal of the foot and a curling up of the toes after plantar stimulation on the seventh day.

The flexion of the segments of the lower limb constitutes the "*reflexes de defense*" which have been so ably studied by Babinski (1896) and his French contemporaries. The usually associated extension of the toes, "*phenomene des orteils*," was noted by him in pathological adult subjects. Vinay (1897) mentioned only the withdrawal of the foot when the plantar surface was stimulated by a pin, while Mumford (1897) mentions only the prehensile reaction of the toes.

Babinski (1898) holds that the extension of the toes is pathological only in adults, it being one of the first and sometimes the only sign of lesions in the pyramidal system. In infants, however, it is the normal physiological response and indicates an undeveloped pyramidal system. Prior to Babinski's time it had been generally assumed, according to Kalischer (1899), that dorsi-flexion or extension of the toes was the normal plantar response. Babinski, therefore, was the first to point out the pathological character of the extensor response. Further differentia are time, effector units, and reflexogenous zones. In the normal flexor response the contraction or movement is much more rapid than in the pathological extension. The last two or three toes are usually involved rather than the big toe (though there are cases in which some toes flex while others extend). The reflex is released best from the middle of the plantar surface rather than from the sides. Extension is not found in normal people nor in cases of functional disease. In patients with total transection of the cord, no plantar response is obtainable.

Cohn (1899), Cestan and Le Sourd (1899), and Kalischer (1899) agree with Babinski in maintaining that the normal infantile plantar response is extensor in character.

Schueler's (1899) examination of one hundred infants did not confirm the prevailing theory, for he found the following results:

No response	40 per cent
Variable	18 per cent
Flexor	30 per cent
Extensor	12 per cent

Collier (1899), in an extensive investigation into the nature of the plantar reflex in normal adults, pathological subjects, and children, confirms most of Babinski's findings. He states that in infants "the response is very brisk, and differs very markedly from the adult reflex. The earliest response is in the great toe, which is drawn back. This is followed by extension and spreading out of all the toes with eversion of the foot and dorsi-flexion of the ankle, and subsequently flexion of the hip and knee" (p. 77). This offers a marked contrast to the "flexed toes, inverted foot, and the early hip response" of the adult.

He proposed that this type of plantar response be called the "infantile response." The similarity it bears to the plantar response of monkeys led him to believe it to be a more primitive type of response.

Collier also found that the normal adult response began to appear at about the age of walking, between the second and third year, and that in the transitional stage now one and then the other form followed upon stimulation, or there might be a mixture of both types with flexion of the outer toes and extension of the big toe. In cases of rickets the infantile response persisted even up to the age of four years. He concluded "that with the establishment of complete cerebral control over the lower limbs the adult form of response to the plantar reflex replaces the infantile response" (p. 78).

Curiously enough he observed that in sleep the reflex was diminished without change in character as far as the infant and adult were concerned, but often children up to the age of twelve manifested a return to the infantile response in deep sleep with normal adult response upon awakening.

Although primarily concerned with the investigation of the plantar reflex in adults, Walton and Paul (1900) and their associates examined some forty infants ranging from a few hours to two weeks old. They found no constancy of response, and question whether or not the movements should merit the term plantar reflex. They state that if either plantar flexion or dorsiflexion predominates, it is the latter.

Leri (1903) found, as a result of his study of 166 infants, that at birth the extension of the toes was the rule and flexion the exception. After three years this condition was reversed except in the case of those infants having maladies supposedly affecting the pyramidal tract. The phenomenon of extension of the toes seemed to disappear with a transitional period, showing fluctuations between the two types, at about the age of five to six months. At about that age the spasmodic activity characteristic of the newborn also disappears. Leri's opinion is that both the extension of the toes and the spasmodic activity are due to the incomplete development of the pyramidal system.

The first really ambitious investigation of the plantar reflex in infants was made by Engstler (1905). He tested a thousand infants ranging from birth to three years of age. The reflex was elicited by lightly stroking the inner surface of the sole with a lead-pencil point. He found it essential that the infant be as quiet as possible; otherwise the effects of the stimulus would be doubtful. In most cases the infants were examined while asleep.

The reflexes were of two distinct types: either (1) a dorsal flexion of the big toe in all its joints with a similar but less pronounced reaction in the other toes, or (2) a plantar flexion of the toes, principally the second to the fifth. Besides these two types there were reactions in which plantar flexion of the little toes occurred with dorsal flexion of the big toe or the latter remained stationary while the little toes underwent plantar flexion. And in some cases there was no reaction of any kind.

When the infants were restless or awake he found, many times, that the reaction extended to other regions than the toes. Thus there was dorsal flexion of the foot, bending at the knee and hip and sometimes a quick withdrawal jerk of the whole leg.

He came to the conclusion that in the newborn and prematurely born dorsal flexion of the toes was the almost invariable response, while in children of the age of three plantar flexion was the rule. The change began in the course of the first and second years. He concluded that dorsal flexion appearing after the age of two years could therefore be considered a pathological sign. Kalischer had sought to link up the change to plantar flexion with walking, but Engstler found many with plantar flexion before they could walk.

In rachitic children the change from the one type of plantar response to the other is retarded.

In a footnote of an article upon defense reflexes (which treats of the history of their investigation), Babinski (1915) mentions some unpublished work by one of his pupils, Mlle Rosenblom, upon the defense reactions of infants. She found these reflexes to be greatly exaggerated up to the end of the fourth month at which time they began to diminish, although the extension of the great toe persevered much longer, being observed even at the age of eighteen months.

Investigation of the reflexes in cases of complete section of the spinal cord showed, according to Dejerine and Mouzon (1915), that destruction of the pyramidal tracts could not be assigned as the cause of the Babinski phenomenon in adults. For in these cases autopsies showed the cord to be severed, and yet plantar flexion was obtained upon stimulation of the plantar surface.

One of the finest and most accurate descriptions of early infantile behavior has been given by Bersot (1920), a Swiss investigator. His work deserves careful study by every student of infantile behavior.

Bersot believes that there is no great change in the activities of the child at birth. For him the extra-uterine life is merely a continuation of the uterine life, and the plantar reflex is one which may occur in the foetus. In the foetus the plantar reflex consists of a flexion of the toes, particularly of the last four, the big toe usually remaining fixed.

At the age of two or three months the reaction is invariably that known as the Babinski sign. Bersot's description of the postural changes in the infant of this age is in most respects entirely descriptive of their reactions during the first two weeks also.

He finds that during the first six months of life the whole cutaneous surface seems to be reflexogenous zone, stimulation of which is capable of releasing a plantar response.

At the age of nine to twelve months the movements of the child begin to show much more coördination. It attempts to stand, and the plantar reaction is now one of flexion. The reflexogenous zone has decreased in size. As the child grows older, its reactions tend to become more localized in the member stimulated. Movements become quicker but diminish in number, intensity and duration. This is true also of the plantar reflex.

Feldman (1921) examined five hundred cases from birth up to the age of seven years, the great majority being under four years of age. He found the response to be totally absent in about 15 per cent of the cases, this percentage agreeing fairly well with Engstler's 11 per cent and Finizio's 5 per cent, but not with Lovett Morse's 35 per cent or Schueler's 40 per cent.

He concludes that the prevailing response in early infancy is

plantar flexion of the big toe. The pyramidal tracts are developed enough, even in utero, to give a normal adult type of response, but circulatory disturbances cause compression upon the incompletely developed pyramidal tracts and as a consequence the Babinski sign may appear. Contrary to other investigators, he finds that the Babinski reflex is the prevailing reaction of premature babies. He notes a sex difference—"Bilateral plantar flexion is at all ages as common in girls as in boys, but bilateral dorsi-flexion is at all age-periods in infancy more common in girls than in boys." He finds bilateral dorsi-flexion of the toes is commoner in those cases having subnormal temperature. Rickets has no effect upon the reflex, and the disappearance of the Babinski sign has nothing to do with the age of walking. He suggests that the variability of the reaction may be due to differential fatigue-ability of muscle groups. He agrees with Bersot that the reflexogenous zone is very diffuse.

One of the most interesting and thorough investigations of the plantar reflex is that made by Rudolf (1922). If he is right in his conclusions, the reflex shows parallel phylogenetic, ontogenetic, and pathological changes. His results are in accord with Feldman's in that both find the first reaction to be plantar flexion, this changing within a few hours or even a few minutes. He disagrees with Feldman as to the significance of the pyramidal tracts.

Babinski (1921), in the light of Bersot's and Lantuejoul's researches, revised his earlier view that dorsi-flexion of the toes is the first reaction of the newborn babe to plantar stimulation.

In view of the disagreement as to the character of the early infantile response Lantuejoul and Hartmann (1923) determined to examine the newborn babe particularly in the first few minutes after birth. In some cases, indeed, where there was a foot presentation the reflex was released even before birth. Their tables show that during the first few minutes after birth there is plantar flexion but that this soon passes over into dorsi-flexion. To the question why this first reaction should be one of plantar flexion they give no definite answer. Three answers, none entirely satisfactory, are given. One, that the reflex immediately after birth is the same as that in utero, is supported from some confirmatory data from the researches of Krabbe, Bersot, and Minkowski. Another theory is

that compression of the limb during delivery is responsible for the reaction. A third theory makes the changes in circulation occurring at birth the causative factor.

The Shermans (1925) with one application of the stimulus to the plantar surface found flexion of the toes in 57.3 per cent of the cases and extension in the remaining. When the stimulus was repeated 5 times in an interval of less than one-half minute, 75.6 per cent of those showing extension at first now gave flexion. Out of a total of 96 cases the final response was 89.6 per cent flexion.

Mathieu and Cornil (1926) in their study of children ranging in age from one day to three years come to the conclusion that the Babinski reflex is a physiological phenomenon in infants incapable of standing. When the infant begins to stand, the big toe flexes in 50 per cent of the cases. When it stands and walks firmly, usually between twelve and eighteen months, all of the toes flex. The argument of the authors is that flexion is necessary for a stable erect posture and that by the repetition of standing and walking, flexion becomes the physiological response to stimulation of the plantar surface.

SUMMARY

The plantar reaction presents three parallel series of changes when studied from the points of view of phylogeny, ontogeny, and pathology.

1. In the phylogenetic series the lowest forms of plantigrade animals either do not respond at all to plantar stimulation or else show plantar flexion. As one ascends the animal scale, the reaction changes to one of extension or dorsi-flexion—this among the higher apes, and then in adult man the reaction again becomes one of plantar flexion.

2. Ontogenetically, the reflex first shows a very limited reflexogenous zone—the reaction being only to plantar stimulation and consisting of a slight flexion of the little toes only. At birth and for the first few minutes or first few hours the infant continues to give a flexor reaction. Within the first few days this changes to one of extension or plantar dorsi-flexion. The greater part of the body surface is now the reflexogenous zone, stimulation of which

will release reactions of the toes, legs, arms, and so on. Stimulation of the plantar surface releases extension and fanning of the toes, flexion of the foot and leg, extension of the arms, crossed plantar flexion, and the like. The most frequent of these are the extension and fanning of the toes and the flexion of the foot. As the infant grows older the reflexogenous zone becomes more specific, and at the age of walking or shortly before, the reaction becomes one of flexion again. This character persists with decreasing intensity until the age of twenty-five to thirty years, during which period it is frequently absent. After this age it augments in intensity with increase in age.

3. Pathologically, in cases of lesions or disturbances of the pyramidal tracts, there is first a complete lack of reaction followed by plantar flexion. This then changes to one of extension, but the final stage of plantar flexion is never attained, the patients thus afflicted living but a short time. Theories of the normal as well as pathological manifestations rest their case upon the development or injury of the pyramidal system.

APPARATUS AND METHOD

PLANTAR APPLICATOR

For releasing the plantar reactions, the stroking of the sole of the foot must be done at a relatively constant pressure. It is difficult to secure this by hand. The device shown in Figure 12 is made up as follows:

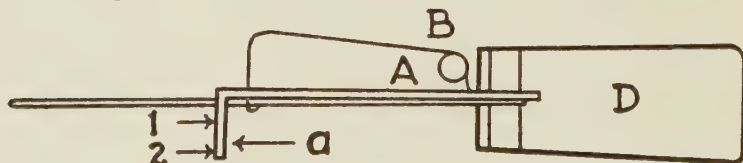


FIG. 12. Plantar applicator for stimulating soles of feet.

(D) a wooden handle. To this is attached a music-wire coiled spring (B) and a piece of metal (A) slotted at *a* to receive a round applicator stick. This stick is of the regular hospital type and can be frequently replaced by a new one. The spring (B) is wound to

such tension that when the end of the applicator stick is in position 1 it will exert a pressure of $2\frac{1}{2}$ g. At the point 2 it exerts $3\frac{1}{2}$ g. as measured by pressing it on the scale pan of a balance. The average pressure is thus about 3 g. for each plantar stimulation. After some practice it is easy to keep the stick about half-way between 1 and 2 while stimulating the infant, thus securing a pressure of about 3 g. The applicator was drawn in the median line of the plantar surface from heel to toe. Each foot was stroked three times alternately, and each stroke was regarded as one stimulation.

The specific movements which are reported are the following: extension of toes (Babinski reflex); flexion of toes; flexion of foot; extension of foot; fanning of toes (*signe d'éventail*); extension of big toe only; flexion of big toe only; extension of leg; flexion of leg; crossed plantar extension of toes.

The tables which follow will show the frequencies and percentages of these reactions. There were 71 infants altogether and we have given this number under the tables. However, some infants may appear in one table and not in another, depending on the condition, asleep or awake, right foot or left foot, and so on.

TABLES, DATA, RESULTS

TABLE CXLI
PLANTAR REACTION
SEX AND RACE DISTRIBUTION
Number of infants—71

	White	Black	Total
Male	14	17	31
Female	24	16	40
Total	38	33	71

Table CXLII on the following page (192) shows:

1. That to plantar stimulation of the right foot when infants are asleep, there were reactions to 88 per cent of the stimulations.
2. The average number of movements per stimulation, of the most frequent reactions were: extension of toes .47; flexion of foot .45.

TABLE CXLII
 PLANTAR REACTION
 RELATION BETWEEN:
 SPECIFIC MOVEMENTS; STIMULATION RIGHT FOOT;
 CONDITION ASLEEP; SEPARATE AGE GROUPS
 Number of infants—71

Age Days	S N	R		Ex. t.		Fx. t.		Fx. f.		Ex. f.	
		f	%	f	Av.	f	Av.	f	Av.	f	Av.
0	13	12	92	7	.54	4	.31	2	.15	0	0
1	28	25	89	15	.53	4	.14	12	.43	0	0
2	6	6	100	3	.50	1	.17	4	.67	0	0
3	24	20	83	8	.33	3	.12	12	.50	0	0
4	27	25	93	13	.48	2	.07	14	.52	0	0
5	22	20	90	9	.41	4	.18	9	.41	1	.04
6	29	24	83	11	.38	2	.09	9	.31	0	0
7	18	18	100	12	.67	1	.05	12	.67	0	0
8	20	18	90	7	.35	1	.05	13	.65	0	0
9	22	14	63	10	.45	0	0	9	.41	0	0
10	19	16	84	12	.63	1	.05	7	.37	0	0
11	12	11	93	4	.33	1	.08	5	.42	0	0
12	6	6	100	5	.83	1	.17	3	.50	0	0
13	5	5	100	2	.40	1	.20	1	.20	0	0
Total...	251	220	88	118	.47	26	.10	112	.45	1	0
% or Av.											

Age Days	Fn. t.		Ex. T.		Fx. T.		Ex. l.		Fx. l.		Cr. Ex.	
	f	Av.	f	Av.	f	Av.	f	Av.	f	Av.	f	Av.
0	2	.15	0	0	0	0	1	.08	0	0	1	.08
1	4	.14	1	.03	1	.03	2	.07	3	.11	1	.03
2	1	.17	0	0	0	0	0	0	0	0	0	0
3	1	.04	1	.04	1	.04	1	.04	1	.04	2	.08
4	1	.04	3	.11	1	.04	1	.04	1	.04	6	.22
5	1	.04	1	.04	0	0	1	.04	8	.36	0	0
6	7	.24	2	.07	0	0	1	.03	0	0	0	0
7	2	.11	1	.05	0	0	0	0	3	.17	1	.05
8	0	0	2	.10	0	0	1	.05	2	.10	0	0
9	3	.14	2	.09	0	0	0	0	3	.14	2	.09
10	3	.16	0	0	0	0	0	0	6	.31	0	0
11	2	.17	2	.17	0	0	0	0	2	.17	0	0
12	2	.03	0	0	0	0	0	0	0	0	0	0
13	1	.20	1	.20	0	0	0	0	0	0	0	0
Total...	30	.14	16	.06	3	.01	8	.03	29	.11	13	.05
% or Av.												

Legend:

S, N, number of stimulations. (Each stroke with the applicator makes one stimulus.)

R, number of times infant reacted. A reaction may include one or more specific movements.

f, %, av., number, centiles, and average of reactions per stimulation for corresponding headings.

Ex. t., extension of toes (Babinski reflex).

Fx. f., flexion of foot.

Fx. t., flexion of toes.

Ex. f., extension of foot.

Fn. t., fanning of toes (signe d'éventail).

Ex. T., extension of big toe only.

Ex. l., extension of leg.

Fx. T., flexion of big toe only.

Fx. l., flexion of leg.

Cr. Ex., crossed plantar extension of toes.

See page 191 for interpretation of data included in this table.

TABLE CXLIII
 PLANTAR REACTION
 RELATION BETWEEN:
 SPECIFIC MOVEMENTS; STIMULATION RIGHT FOOT;
 CONDITION AWAKE; SEPARATE AGE GROUPS
 Number of infants—71

Age	S N	R		Ex. t.		Fx. t.		Fx. f.		Ex. f.	
		f	%	f	Av.	f	Av.	f	Av.	f	Av.
0	17	16	94	13	.76	2	.12	8	.47	0	0
1	13	13	100	10	.77	2	.01	1	.08	0	0
2	15	15	100	11	.73	2	.01	0	0	0	0
3	15	15	100	12	.80	1	.07	8	.53	0	0
4	14	14	100	8	.57	3	.21	2	.14	0	0
5	6	5	83	3	.50	0	0	0	0	0	0
6	3	2	67	2	.67	0	0	0	0	0	0
7	13	11	85	8	.61	0	0	3	.23	0	0
8	7	7	100	3	.43	2	.28	2	.28	0	0
9	13	13	100	11	.85	1	.08	9	.69	0	0
10	5	5	100	3	.60	1	.20	2	.40	0	0
11	6	6	100	3	.50	1	.17	1	.17	0	0
13	5	5	100	5	1.00	0	0	0	0	0	0
14	3	3	100	2	.67	0	0	1	.33	0	0
17	2	2	100	0	0	1	.50	0	0	0	0
Total...	137	132	96	94	.69	16	.12	37	.27	0	0
% or Av.											

Age	Fn. t.		Ex. T.		Fx. T.		Ex. l.		Fx. l.		Cr. Ex.	
	f	Av.	f	Av.	f	Av.	f	Av.	f	Av.	f	Av.
0	4	.23	0	0	0	0	2	.12	0	0	2	.12
1	6	.46	0	0	0	0	1	.08	2	.15	2	.15
2	8	.53	3	.20	0	0	3	.20	0	0	2	.13
3	6	.33	1	.07	0	0	1	.07	0	0	1	.07
4	7	.50	2	.14	0	0	0	0	0	0	0	0
5	3	.50	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	2	.66	0	0
7	0	0	1	.08	0	0	0	0	0	0	0	0
8	1	.01	1	.01	0	0	0	0	3	.43	0	0
9	2	.15	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	1	.20	0	0
11	2	.33	1	.17	0	0	0	0	2	.33	1	.17
13	1	.20	0	0	0	0	0	0	1	.20	1	.20
14	0	0	0	0	0	0	0	0	1	.33	0	0
17	0	0	1	.50	0	0	0	0	0	0	0	0
Total...	39	.28	10	.07	0	0	7	.05	12	.09	10	.07
% or Av.												

Legend: Same as for Table CXLII.

Table CXLIII shows:

1. That to plantar stimulation of the right foot when infants are awake, there were reactions to 96 per cent of the stimulations.
2. The average number of movements per stimulation, of the most frequent reactions were: extension of toes .69; fanning of toes .28; flexion of foot .27.

TABLE CXLIV
 PLANTAR REACTION
 RELATION BETWEEN:
 SPECIFIC MOVEMENTS; STIMULATION LEFT FOOT;
 CONDITION ASLEEP; SEPARATE AGE GROUPS
 Number of infants—71

Age	S N	R		Ex. t.		Fx. t.		Fx. f.		Ex. f.	
		f	%	f	Av.	f	Av.	f	Av.	f	Av.
0	12	12	100	6	.50	4	.33	5	.42	0	.0
1	27	22	81	12	.44	4	.15	11	.41	0	.0
2	6	5	83	2	.33	1	.17	2	.33	0	.0
3	25	24	96	5	.20	5	.20	14	.56	1	.04
4	24	22	91	10	.42	1	.04	15	.62	5	.21
5	23	21	91	11	.48	4	.17	8	.35	1	.04
6	27	23	85	15	.55	3	.11	8	.30	0	.0
7	18	14	78	10	.55	1	.05	9	.50	0	.0
8	21	17	81	8	.38	1	.05	13	.62	0	.0
9	18	16	88	10	.55	0	.0	10	.55	0	.0
10	20	14	70	10	.50	1	.05	2	.10	0	.0
11	12	9	75	4	.33	1	.08	3	.25	0	.0
12	6	3	50	2	.33	1	.17	1	.17	0	.0
13	5	4	80	3	.60	1	.20	0	.0	0	.0
Total...	244	206		108		28	.11	101	.41	7	.03
% or Av.			84		.44		.11		.41		.03

Age	Fn. t.		Ex. T.		Fx. T.		Ex. l.		Fx. l.		Cr. Ex.	
	f	Av.	f	Av.	f	Av.	f	Av.	f	Av.	f	Av.
0	2	.17	1	.08	0	.0	0	.0	1	.08	1	.08
1	3	.11	0	.0	2	.07	1	.04	4	.15	0	.0
2	1	.17	1	.17	0	.0	1	.17	1	.17	0	.0
3	2	.08	4	.16	0	.0	2	.08	1	.04	0	.0
4	2	.08	3	.12	0	.0	0	.0	1	.04	0	.0
5	1	.04	4	.17	0	.0	0	.0	7	.30	0	.0
6	5	.18	1	.04	0	.0	1	.04	1	.04	1	.04
7	3	.17	1	.05	0	.0	0	.0	3	.17	0	.0
8	1	.05	2	.10	0	.0	0	.0	1	.05	0	.0
9	1	.05	1	.05	0	.0	1	.05	4	.22	0	.0
10	7	.35	1	.05	0	.0	0	.0	5	.25	0	.0
11	3	.25	2	.12	0	.0	0	.0	2	.13	0	.0
12	0	.0	1	.02	0	.0	0	.0	0	.0	0	.0
13	0	.0	0	.0	0	.0	0	.0	0	.0	0	.0
Total...	31		22		2		6		31		2	
% or Av.		.13		.09		.01		.02		.13		.01

Legend: Same as for Table CXLII.

Table CXLIV shows:

1. That to plantar stimulation of the left foot when infants were asleep, there were reactions to 84 per cent of the stimulations.

2. The average number of movements per stimulation of the most frequent reactions were: extension of toes .44; flexion of foot .41; fanning of toes .13; flexion of leg .13; flexion of toes .11.

TABLE CXLV
 PLANTAR REACTION
 RELATION BETWEEN:
 SPECIFIC MOVEMENTS; STIMULATION LEFT FOOT;
 CONDITION AWAKE; SEPARATE AGE GROUPS
 Number of infants—71

Age	S N	R		Ex. t.		Fx. t.		Fx. f.		Ex. f.	
		f	%	f	Av.	f	Av.	f	Av.	f	Av.
0	17	16	94	10	.59	4	.23	7	.41	0	0
1	12	11	92	7	.58	2	.17	1	.08	0	0
2	15	15	100	11	.73	3	.20	0	0	0	0
3	13	13	100	12	.92	1	.08	6	.05	0	0
4	14	14	100	7	.50	4	.28	1	.07	1	.07
5	6	5	83	2	.33	1	.17	2	.33	0	0
6	4	3	75	3	.75	0	0	0	0	0	0
7	13	11	85	8	.61	1	.08	6	.46	0	0
8	6	6	100	5	.83	2	.33	2	.33	0	0
9	11	11	100	8	.73	1	.09	6	.54	0	0
10	6	6	100	3	.50	1	.17	4	.67	0	0
11	6	6	100	3	.50	0	0	1	.17	0	0
13	5	5	100	5	1.00	0	0	0	0	0	0
14	3	3	100	2	.67	1	.33	0	0	0	0
17	2	2	100	2	1.00	0	0	0	0	0	0
Total ...	133	127	95	88	.66	21	.16	36	.27	1	.01
% or Av.											

Age	Fn. t.		Ex. T.		Fx. T.		Ex. I.		Fx. I.		Cr. Ex.	
	f	Av.	f	Av.	f	Av.	f	Av.	f	Av.	f	Av.
0	5	.29	0	0	0	0	3	.18	0	0	0	0
1	6	.50	1	.08	0	0	0	0	1	.08	0	0
2	9	.60	3	.20	0	0	3	.20	1	.07	2	.13
3	7	.54	0	0	0	0	1	.08	0	0	1	.08
4	7	.50	2	.14	0	0	0	0	0	0	0	0
5	1	.17	0	0	0	0	0	0	0	0	0	0
6	2	.50	0	0	0	0	0	0	2	.50	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	1	.17	1	.17	0	0
9	3	.27	0	0	0	0	1	.09	0	0	0	0
10	0	0	0	0	0	0	0	0	1	.17	0	0
11	2	.33	0	0	0	0	0	0	3	.50	0	0
13	4	.80	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	1	.33	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0
Total ...	46	.34	6	.04	0	0	8	.06	10	.07	3	.02
% or Av.												

Legend: Same as for Table CXLII.

Table CXLV shows:

1. That to plantar stimulation of the left foot when infants were awake, there were reactions to 95 per cent of the stimulations.

2. The average number of movements per stimulation of the most frequent reactions were: extension of toes .66; fanning of toes .34; flexion of foot .27; flexion of toes .16.

TABLE CXLVI
PLANTAR REACTION
RELATION BETWEEN:
REACTIONS; STIMULATION OF BOTH FEET;
CONDITIONS ASLEEP AND AWAKE; SEPARATE AGE GROUPS
Number of infants—71

Age Days	Asleep				Awake				Av. %
	Rt. Ft.		L. Ft.		Rt. Ft.		L. Ft.		
	S, N	R, %	S, N	R, %	S, N	R, %	S, N	R, %	
0	13	92	12	100	17	94	17	94	95
1	28	89	27	81	13	100	12	92	90
2	6	100	6	83	15	100	15	100	95
3	24	83	25	96	15	100	13	100	95
4	27	93	24	92	14	100	14	100	96
5	22	91	23	91	6	83	6	83	87
6	29	83	27	85	3	67	4	75	77
7	18	100	18	78	13	85	13	85	87
8	20	90	21	81	7	100	6	100	93
9	22	64	18	89	13	100	11	100	88
10	19	84	20	70	5	100	6	100	88
11	12	92	12	75	6	100	6	100	92
12	6	100	6	50	.....	.....	.....	.....	75
13	5	100	5	80	5	100	5	100	95
14	.....	.....	.....	.....	3	100	3	100	100
17	.....	.....	.....	.....	2	100	2	100	100
Total	251		244		137		133		
Av. %		88		84		96		95	91
Rt. Ft., 91% ; L. Ft., 88% ; Awake, 96% ; Asleep, 86%.									

Legend:

Rt. Ft., L. Ft., right or left foot.

S, N, number of stimulations.

R, percentage of reactions per stimulation.

Av. %, average centiles for corresponding headings.

Table CXLVI shows:

1. That there were 91 per cent reactions to plantar stimulation when all age groups were combined. There was some indication of lowered activity between the fifth day 87 per cent, and the tenth day 92 per cent. The lowest percentage of activity, at the age level of twelve days, 75 per cent, may be partially explained by the limited number of cases.

2. That there was not much difference between the right foot 91 per cent, and the left foot 88 per cent.

3. That the reactions were slightly more frequent when awake 96 per cent, than when asleep 86 per cent. This is usually stated in the reciprocal form "that the plantar reaction is depressed during sleep."

TABLE CXLVII

PLANTAR REACTION

RELATION BETWEEN:

SPECIFIC MOVEMENTS; STIMULATION OF BOTH FEET;
CONDITIONS, ASLEEP AND AWAKE, ALL AGES COMBINED

Number of infants—71

Sp. M.	ASLEEP		AWAKE	
	Rt. Ft. Av.	L. Ft. Av.	Rt. Ft. Av.	L. Ft. Av.
Exten. toes	.47	.44	.69	.66
Flex. toes	.10	.11	.12	.16
Flex foot	.45	.41	.27	.27
Exten. foot	.0	.03	.0	.01
Fanning toes	.14	.13	.23	.34
Exten. L. Toe.....	.06	.09	.07	.04
Flex. L. Toe.....	.01	.01	.0	.0
Exten. leg	.03	.02	.05	.06
Flex. leg	.11	.13	.09	.07
Cr. Exten. toes.....	.05	.01	.07	.02

Legend: Same as for Table CXLII.

Av., average number of specific movements per stimulation.

Table CXLVII shows:

1. That there are 4 specific movements which enter into the plantar reaction to a considerable extent: extension of the toes (the original Babinski reflex); flexion of the foot; flexion of the toes; fanning of the toes.

TABLE CXLVIII

PLANTAR REACTION

RELATION BETWEEN:

SPECIFIC MOVEMENTS OCCURRING ALONE; STIMULATION OF BOTH FEET;
CONDITIONS ASLEEP AND AWAKE; ALL AGES COMBINED

Sp. M.	Asleep		Awake		Totals	
	f	%	f	%	f	%
Exten. toes	38	9	40	15	78	11
Flex. toes	19	5	16	6	35	5
Flex. foot	85	20	15	6	100	15
Exten. foot	2	0	2	0	4	1
Fanning toes	0	0	0	0	0	0
Exten. L. Toe	20	5	3	1	23	3
Flex. L. Toe	2	0	0	0	2	0
Exten. leg	5	1	2	1	7	1
Flex. leg	9	2	6	2	15	2
Cr. Exten. toes	3	1	0	0	3	0

Legend: This table differs from Table CXLVII in that it gives only those reactions in which only one movement occurred to one stimulation.

f, number of cases in which only the specific movement after the corresponding heading, occurred.

%, the value of f in centiles ($100f/\text{Total R.}$).

Total number of reactions 685 including both simple and complex.

Table CXLVIII shows:

1. That simple specific movements to plantar stimulation are not very frequent. The Babinski reflex (extension of the toes) occurs only in 11 per cent of the cases; flexion of the foot is most frequent 15 per cent.

TABLE CXLIX
PLANTAR REACTION
RELATION BETWEEN:
SPREAD OF SPECIFIC MOVEMENTS; STIMULATION OF BOTH FEET;
ALL CONDITIONS; ALL AGE GROUPS

Sp. M. Gr.	Table CXLII		Table CXLIII		Table CXLIV		Table CXLV		Sum	
	f	%	f	%	f	%	f	%	f	%
Toes	206	58	169	75	193	57	164	75	732	64
Feet	113	32	37	16	108	32	37	17	295	26
Legs	37	10	19	9	37	11	18	8	111	10
Total....	356		225		338		219		1138	
Total %..		100		100		100		100		100

Legend:

Sp. M. Gr., specific movement groups.

toes, includes ex. t., fx. t., fn. t., ex. T., fx. T., Cr. ex.

feet, includes fx. f., ex. f.

legs, includes fx. l., ex. l.

Table CXLII, CXLIII, etc., tables from which data were taken.

f, sum of specific movements, for groups toes, feet, legs.

Sum: f, horizontal sum of f; %, percentage of total 1138.

Total, sum of frequencies and centiles for corresponding headings.

Table CXLIX shows:

1. This table was designed to test the hypothesis that the cutaneous surface of the infant may be regarded as a reflexogenous zone as proposed by Bersot (1920). The results from the plantar stimulation make it possible to extend this hypothesis to the following statement: The sole of the foot may be regarded as a reflexogenous zone. Upon stimulation in plantar fashion the reaction spread is first to movements of the smallest segments near the source of stimulation (toes 64 per cent), then to movements of the next larger segments (feet 26 per cent), and then to still larger segments (legs 10 per cent). The observation of the reactions to the other forms of stimuli which were used does not show this spread nearly so well. However, at birth not all cutaneous surfaces are equally developed. Vision, for instance, seems to be

much farther advanced than the other sense organs. The reactions to light show a greater degree of specificity than the reactions to the other stimuli. The reactions to cold are most frequent, but they are not so specific.

SUMMARY

The experiments upon the plantar response show no consistent trend in the percentage of reactions to stimulations with increase in age either in the asleep or awake conditions, although it is evident that the age groups from 5-7 days show a smaller percentage of reactions than the other age groups in the awake condition (Table CXLVI). The difference in percentage of reactions between the right and left foot (right foot 91 per cent; left foot 88 per cent) is probably too small to be significant, whereas the difference between the awake and asleep conditions (awake 96 per cent; asleep 86 per cent) is much larger.

It is demonstrated that the plantar response is usually not a simple reaction but involves a complex of reactions of which the most important are extension of toes, flexion of the foot, flexion of the toes, and fanning of the toes (Table CXLVII). Of single reactions in response to plantar stimulation, flexion of the foot and extension of the toes are most numerous (Table CXLVIII).

Analysis of specific movements according to age groups reveals in the asleep condition a higher percentage of flexion of the toes on the first day than thereafter (Tables CXLII and CXLIV). This relationship does not seem to hold in the awake group.

Analysis of the percentage of specific movements in the effector segments—toes, feet, and legs—throws considerable light upon the specificity of reflexogenous zones. It is quite apparent from Table CXLIX that in this reflex, at least, there is a spread in the activity of the effector segments involved from the toes, which are nearest the zone, to the legs, which are most remote from the zone of stimulation. This evidence is contributory to the hypothesis set forth by Bersot to the effect that the infant's behavior is more or less generalized rather than highly specific. There seems, indeed, to be a kind of gradient of activity, the range or length of which becomes shorter, that is, more specific or limited with increase in age.

THE SUCKING REACTION

HISTORICAL

This reaction is one of the most conspicuous in the newborn child's repertory. It is therefore strange to find that comparatively few studies have been made of it. Of those observations which have been made, the earlier ones seem to be just as complete as the later ones. It is indeed curious to note that the plantar reaction which, as far as the infant is concerned, has apparently no value should have been made the subject of numerous studies, while one of such tremendous importance to the infant as the sucking reflex should have been by comparison neglected.

The nursing child has been the theme of many a poetic flight, but it is not worth while to go into any of them. There is one remark by that keen-eyed observer, Samuel Pepys (1667), which is just as valuable as the subsequent observations of the same phenomenon.

"They tell me what I did not know that a child (as this do) will hunt up and down with its mouth if you touch the cheek of it with your finger's end for a nipple, and fit its mouth for sucking, but this hath not sucked yet, she having no nipples" (p. 222).

One of the best descriptions of the sucking reflex, even today, is that made by Preyer (1901). He says, "Sucking belongs to the earliest coördinated movements of man; it is associated directly with swallowing, and has been repeatedly perceived even before the child was fully born . . . I touched with my finger the tongue of a child, born at the right time, and moved my finger to and fro, or turned it on the upper surface of the tongue, three minutes after the head had emerged—the child was already crying feebly as soon as the mouth was free—the babe immediately stopped crying and sucked briskly, but not when I merely touched the lips or put the finger between them" (pp. 257-58).

Swallowing movements are not necessary for prolonged sucking, and under normal conditions the reflex is present only when the infant is hungry. Preyer considers it an unlearned, instinctive act.

Not every object touching the lips will release the sucking response, "For it is not any object whatever put into the mouth

that is sucked, but only certain objects, not too large, not too rough, not too hot or too cold, and not of a strongly bitter, or sour, or salt taste. In general, hungry children suck at their own fingers from the first days" (p. 261).

Since Preyer's time there have been three or four special studies upon the sucking and allied reflexes. One of these, the lip reflex, investigated by Thompson (1903), has been named after him. His work is reviewed by Lambanzi and Piannetta (1906).

They examined some 24 infants, 13 ranging from 10 days to 7 months, 8 from 1 to 2 years, and 3 of 3 years. Their results do not confirm Thompson's statement that the reflex is absent when the child is awake, but they do show that it is more difficult to elicit a clear-cut response.

Fifty-eight normal adults ranging in age from 14-57 years were then tested and the reflex elicited in only one case and that a man addicted to drink. With this as a foundation they set out to see whether, as Toulouse and Vurpas had found, the reflex reappeared in pathological cases. Their results show that it does and that it appears in at least half of the insane, the percentage varying according to the type of insanity from 36.84 per cent in epilepsy to 84.21 per cent in senile dementia.

Blanton (1917), in testing out Thompson's lip reflex by tapping with the tip of the finger below or above the corners of the mouth of the sleeping baby, found the reaction to be one of closing and pouting of the lips into the nursing position. With regard to sucking and swallowing, this investigator says, "Nothing but the most marked retardation or injury seems to affect this reflex. Swallowing, and sucking, tongue, lip, and cheek reflexes make up the feeding reflex. The evidence is strongly in favor of the fact that weakness in the ability to swallow is at least suggestive of mental retardation, whereas sucking is present at birth in most infants."

Stimulating cheek and chin brought about a movement of the mouth in the direction of the touch when the infant was only a few hours old. Koffka (1925) chooses the sucking reflex as an example of instinctive action. He uses Preyer as his source book.

From the literature, we note that the sucking reaction is one of the earliest coördinated reactions of the infant. It may be released

even before the child is completely delivered. The reaction becomes better coördinated and more efficient within the first few days. It is a complex reaction involving many muscle groups and a coördination with the swallowing reaction. Any deficiency in this group of reactions is considered a sign of retarded development or serious defect. The reaction is most readily released when the infant is asleep or hungry. It is difficult to release when the infant has just been fed. With increasing age the sucking and lip reflexes disappear, but reappear in certain types of insanity.

TABLES, DATA, RESULTS

Four different areas of the face were lightly touched with the forefinger: (a) the cheek nearest the experimenter, about two inches from the corner of the infant's mouth, (b) a spot just below the lips on the chin, (c) a spot just above the lips, under the nose, (d) the lips themselves.

This was one of the earlier experiments and no report was made of any specific reactions other than those of sucking. Where sucking did not occur to stimulation, "no reaction" was reported. No careful check was kept on the number of infants for this particular reaction. The approximate number of infants was twenty.

TABLE CL
SUCKING REACTION
RELATION BETWEEN:
REACTIONS; STIMULATION OF SEPARATE MOUTH AREAS;
CONDITION ASLEEP; SEPARATE AGE GROUPS
Number of infants—About 20

Age Days	Cheeks		B. Lips		Ab. Lips		Lips	
	S, N	R, %	S, N	R, %	S, N	R, %	S, N	R, %
0	4	25	4	0	1	0	4	50
1	11	18	11	18	4	25	11	55
2	3	0	3	0	1	100	3	33
3	11	9	9	0	3	67	11	45
4	9	11	9	0	1	0	9	22
5	6	0	6	0	0	0	6	33
6	7	0	8	13	2	0	8	25
7	9	0	8	0	0	0	10	70
8	9	11	8	25	1	100	9	67
9	5	0	5	40	1	100	6	50
10	7	0	7	29	0	0	7	71
11	3	0	3	0	0	0	3	67
12	4	0	4	0	1	0	5	40
13	1	0	1	0	0	0	2	50
14	1	0	1	100	0	0	1	100
T.S. ...	90		87		15		95	
Av. %...		7		12		40		49

Legend for Table CL:

Cheek, light touch with finger on either cheek about 2 inches from corner of mouth.

B. Lips, light touch just below lips on chin.

Ab. Lips, above lips under nose.

Lips, direct touch on lips.

R, unambiguous sucking reaction.

S, N, number of stimulations per area given.

%, percentage of sucking reactions per stimulation.

T. S., total number of stimulations.

av. %, average percentage of sucking reactions per stimulation.

Table CL shows:

1. When infants are asleep there are 49 per cent sucking reactions to direct stimulation of lips, and 40 per cent to stimulation above lips.

2. That to stimulation of the cheeks there are only 7 per cent reactions.

TABLE CLI
SUCKING REACTION
RELATION BETWEEN:
REACTIONS; STIMULATION OF SEPARATE MOUTH AREAS;
CONDITION AWAKE; SEPARATE AGE GROUPS
Number of infants—About 20

Age Days	Cheeks		B. Lips		Ab. Lips		Lips	
	S, N	R, %	S, N	R, %	S, N	R, %	S, N	R, %
0	6	33	7	43	3	67	6	83
1	5	20	5	0	1	0	5	80
2	5	40	5	20	2	100	5	40
3	4	25	5	20	1	0	5	60
4	6	0	6	0	3	0	7	57
5	7	29	7	29	2	50	7	43
6	4	0	4	25	1	0	5	60
7	7	14	7	14	1	0	6	50
8	3	0	3	0	0	0	5	40
9	4	0	4	25	0	0	4	75
10	1	0	1	0	0	0	1	0
11	6	0	6	0	1	0	7	71
12	3	0	3	0	1	0	2	67
13	1	0	1	100	0	0	1	100
14								
15	1	0	0	0	0	0	1	100
16	2	0	2	100	0	0	2	100
17	2	0	0	0	1	0	2	100
T.f.	67		69		17		72	
Av. % ..		13		19		29		63

Legend: Same as for Table CL.

Table CLI shows:

1. When infants are awake there are 63 per cent sucking reactions to direct stimulation of the lips.

2. That to stimulation of the cheek there are only 13 per cent reactions.

3. That a comparison between asleep and awake shows the reaction occurring most frequently while awake. However, if the reaction depends on the length of the interval between the last feeding and the time of stimulation, this is to be expected, since the probability of being awake becomes greater as the next feeding period approaches.

TABLE CLII
SUCKING REACTION
RELATION BETWEEN:
REACTIONS; SEPARATE AREAS TOUCHED; CONDITIONS ASLEEP
AND AWAKE COMBINED; SEPARATE AGE GROUPS
Number of infants—71

Age Days	Cheeks		B. Lips		Ab. Lips		Lips	
	S, N	R, %	S, N	R, %	S, N	R, %	S, N	R, %
0	10	30	11	27	4	50	10	70
1	16	19	16	13	5	20	16	64
2	8	25	8	13	3	100	8	38
3	15	13	14	7	4	50	16	50
4	15	7	15	0	4	0	10	38
5	13	15	11	15	2	50	13	39
6	11	0	12	17	3	0	13	39
7	16	7	15	7	1	0	16	63
8	12	8	11	18	1	0	14	57
9	9	0	9	33	1	100	10	60
10	8	0	8	25	0	0	8	63
11	9	0	9	0	1	0	10	70
12	7	0	7	0	2	0	8	50
13	2	0	2	50	0	0	3	67
14	1	0	1	100	0	0	1	100
15	1	0	1	0	0	0	1	100
16	2	0	2	100	0	0	2	100
17	2	0	2	0	1	0	2	100
T.S.....	157		156		32		167	
Av. %..		10		15		34		55

Legend: Same as for Table CL.

Table CLII shows:

1. That when both conditions, asleep and awake, are combined, the frequency of the sucking reaction occurs in the following order: direct stimulation of lips 55 per cent; stimulation above lips 34 per cent; below lips 15 per cent; on cheeks 10 per cent.

SUMMARY

For this investigation the term sucking reaction includes such movements as "pursing" of the lips, slight sucking and pronounced

sucking reactions. In the first days of life the sensory area for the sucking reaction covers the lips, the surface above and below the lips, cheeks, tongue, and interior of the mouth. With the applicator type of stimulation, the lips are always stimulated and we find an increase in the sucking reactions with an increase in age (Table LXXXIII). With the medicine dropper type of stimulation, the lips are not stimulated, and there is a decrease in the sucking reactions with an increase in age (Table CXV).

This seems to indicate that with increasing age the sensory area for sucking becomes more specific for lip stimulation. With the exception of the stimulations of the lip area, the sucking reaction is diminished in sleep. Before the conditions of asleep and awake can be compared with each other, the relation between the frequency of the sucking reaction with respect to the interval between the last feeding and the time of stimulation should be investigated.

The facts seem to justify the conclusion that the most frequent activity of the infant at birth is that of sucking. Thermal, gustatory, and also olfactory forms of stimulation release sucking reactions. For sugar solutions these reactions increase from the time of birth on, but for the temperature stimuli, the olfactory, and the remaining taste stimuli, the sucking reactions decrease as the infant becomes older. The facial reactions, the body reactions, and the reactions of the extremities, on the other hand, increase for some of the stimuli from birth on. This means that with increasing age the stimulus for sucking becomes more specific.

CHAPTER X

GENERAL CONCLUSIONS

LITERATURE

The literature on the earlier work on infant behavior is so scattered and so difficult to secure that we felt this as a real limitation. After some time spent in Washington going over the titles in the Surgeon-General's and the Congressional Libraries in Washington, and after the inspection of about five thousand titles, the work did not seem to be worth while. Much of the earlier work on infant behavior was done under such doubtful experimental conditions, and the results are so poorly reported that we decided to limit our bibliography to those titles which seemed to report work that was of a fundamental character.

In this there is, of course, the danger of overlooking contributions of great importance which should be given priority. Since writing this monograph, Peiper's (1928) *Hirntaetigkeit des Saeuglings* has appeared. He has performed in a condensed form the task which we attempted in a larger way. All those interested in infant behavior owe a debt of gratitude to Peiper for this work. Yet the contradictory character of the results he reports is most pronounced. This is easily understood. The earlier experiments were conducted by busy physicians under clinical conditions that were inadequate. The observations were made on separate infants without control or a careful check against the physiological conditions. In most cases, the experimenter, when working in the sense fields, used stimuli that were much stronger than those which ordinarily occur.

What is the infant? After this series of investigations it seems that we should be able to make some generalizations which will serve as a working hypothesis for further investigations. However, in actually trying to formulate the net result of our work, we feel that we have only begun to see the complexities in the investigations of infant behavior. Yet our general results seem to warrant some hypothetical formulations.

Considered as an organism, various theories have been advanced regarding the newborn infant. One of the most general notions is that the infant is for the most part a man in miniature, lacking, it is true, the powers of speech, locomotion, and reproduction, but endowed with most of the other forms of activity, however imperfect. This popular view represents the same anthropomorphic interpretation as is so common in the interpretation of the behavior of other animals, domesticated and wild.

A second theory holds that the infant is primarily a reflex organism. That is to say, the behavior of the infant consists in a number of quite specific simple reflexes and a few more complicated but none the less specific reactions called primary emotions, instincts, and so forth. On this theory, development in the direction of adult behavior must consist of a modification and variation of these primary specific reactions.

According to a third theory, the behavior of the infant is not at all precise and specific, but it consists in generalized behavior with the activity greatest in those bodily segments which are nearest to the region stimulated, and a decrease in the magnitude and frequency of the activity roughly corresponding to the distance from the zone stimulated (Bersot and Minkowski). An early variant of this is the doctrine, "From Fundamental to Accessory." This doctrine has been variously stated, but if it is expressed in this form, that in the early stages the larger muscle groups are first coördinated and that there is a progressive increase in coördination with the finer smaller muscle adjustments, it best fits in with the theory stated above and also with the experimental results of our investigations.

This increasing specificity may be ascribed to developmental (maturation) factors, or environmental factors, or both. For those who maintain that "maturation" is the most important factor in accounting for changes in behavior, training or education must play a minor rôle. Those who stress the environment will insist that training will account for most of the specificity both as to time and the form of appearance. Specific experiments designed to show the relative effects of both maturation and training must furnish the answer. With the greater interest that is gradually

developing in the study of infant behavior, it will not be long before many of the controversial topics will become the bases for controlled experimentation.

From our own investigations we may safely conclude that the infant is not a man in miniature; for, although it sneezes, coughs, hiccoughs, blinks, cries, and so forth, these actions are not peculiarly human characteristics. On the whole, however, the infant's repertory of reactions, limited as it is, does adjust it to its own environment.

The infant at birth represents an organism in which differentiation has proceeded to the point where there are many effectors and many receptors. Its behavior, however, is generalized, that is, stimulation of almost any group of receptors by almost any kind of stimulus will lead to a response in almost any part of the organism. The reaction tends, however, to manifest itself most strongly in that part of the organism which is stimulated, and from there spreads out with decreasing frequency and intensity to the other segments of the body. This does not mean that the activity within any given segment is well coördinated.

The infant is not to be regarded as a spinal frog with reactions of the "wiping" reflex type. The newborn infant is equipped with quite a number of reflexes, but the degree of their specificity and their significance seem to have been unduly exaggerated. For the most part these reflexes are vegetative in character, and even the others are in no way peculiar to human beings.

Even within the first two weeks one may observe a restriction of the generalized reactions as indicated by a decrease in the number of effector segments involved and an increasing specificity in the reactions to stimuli. We are not in a position to ascribe this increasing specificity of function as primarily due to either maturation or environmental factors. Before much can be done along these lines it is necessary to develop an experimental technique which gives more decided environmental variations than those now surrounding infants, with a high degree of assurance that these changes will not hinder the subsequent development of the infant.

This research, as was to be expected, has produced more problems than it has solved. It has suggested the possibility that a

complete picture of activity, both quantitative and qualitative, may reveal sex and race differences in behavior at this early stage when the environment is more uniform than it will ever be afterwards. It has pointed out the futility of assuming that an infant's sensory reactions are similar to those of adults, and has shown that to speak at all confidently on this subject will require intensive experimentation in each sense field, with greater control and analysis of the exact nature and measurement of the physical stimuli. It has shown that a study of adaptive reactions (sucking, reactions to temperature, and so forth) will probably yield more significant results than the enumeration and description of fairly specific reflexes of little social significance.

A study of changes in these may enable us to formulate laws of development. It also appears possible to secure norms of activity which will supplement our stabilimeter measures by such measures as basal metabolism, hydrogen ion concentration and the like.

THE CONTROL PERIOD

We have found this of the greatest significance. Many of our conclusions have been modified in the light of what has happened during the control period. When one finds, for instance, that a specific movement always follows upon a specific stimulus, one is disposed to conclude that the response is in some way identified with the stimulus. When, however, it is found that the given reaction occurs about as frequently without any external stimulation, and that this seems to be merely a day in which "fanning of the toes" is occurring a great deal, one loses some of his assurance as to the specificity of this stimulus-response category.

One of the difficulties of earlier experimentation can be traced to the fact that the experimenter used stimuli which were too strong. The practice of using strong stimuli is hard to overcome. The experimenter in psychology has developed his technique in such a way that there is usually something to report after the subject has been through the stimulating conditions. When there is nothing to report the experimenter regards this as a failure. Consequently, with infants, and with moderate strengths of stimuli, the protocol "no reaction" appears so often that the experi-

menter is likely to increase the stimulus strength until the "apparent" failures become fewer. When this is done, reactions are secured, but they are not specific reactions to the kind of stimulus that is used. Any stimulus that is made strong enough will release a reaction, but when these reactions are to terminal forms of stimulation and do not reveal the specific character of the reaction, nothing is gained. Of course, where it is possible to apply the stimulus in various intensities or steps, the form of reaction is more easily determined. But where only a single stimulus intensity can be used, it is better to use that strength which the experimenter regards as medium, or the strength to which the infants react under normal conditions.

MEASUREMENTS OF INFANT BEHAVIOR

The qualitative description of the movements of infants, and particularly as segmental movements, presents certain difficulties upon which investigators should agree. It is, of course, always difficult to describe a movement and theoretically a movement can only be adequately described by a succession of coördinates. We have not yet reached this degree of accuracy in psychology. To describe a yawn in terms of the spatial and temporal coördinates of the observable mouth and throat movements is hardly practicable, and it is doubtful whether such a geometrical description would be actually recognized as a yawn. A method which would lend itself best to child behavior research would be one in which it would be possible to isolate some specific form of stimulation and show that in all infants of this age this stimulation is followed by a specific reaction. However, our results do not indicate such specificity. For instance, stimulation of the lips of a newborn infant is followed by the sucking reaction in over 90 per cent of the infants of a given age, but a stimulation of the cheeks, eyes, temperature, taste, smell, and so forth, will also produce it.

That is to say, sucking is a specific reaction to stimulation of the lips, but it is a reaction to many other stimuli also. Shall we say that this fact makes it less specific? Of course, if we define specific to mean that only one form of reaction should follow one form of stimulation, sucking is not specific. Much of the controversy

as to the nature of instinctive behavior has arisen out of this double definition of instinct. The fact that seems most pronounced in our own investigations is that any stimulus may release any reaction. This, of course, is opposed to any definition of instinct in the historical sense of the term. If we ask, what the infant brings into the world with him in the way of sensorimotor equipment, we are disposed to answer, not much. There seems to be a minimum equipment primarily designed to get food into the alimentary canal at regular intervals. This means that those movements which have to do with swallowing are fairly well coördinated; those movements which have to do with getting food, piercing cries, high and almost convulsive strampling activity, while not coördinated in the muscular sense, do act as strong stimuli on the social environment so that something is done about it. This something is usually the feeding of the child. To the most unfavorable external condition, cold, the infant reacts in about the same way.

It seems certain that such well-coördinated reactions as those implied by the terms love, rage, and fear, do not exist at this early age. When we say that they do appear later as a product of growth and maturation, this is merely a restatement of the fact that they do appear. The main problem as to how they develop out of the limited infantile mechanism is a genetic problem which calls for further experimentation. That is to say, if there is a fear reaction to a loud sudden noise at one month we must get the intermediate stages in which a loud sound releases a minimum of response until we get the fear reaction. Whether what is actually secured is anything like what is called the adult fear reaction is another matter which can take on a very controversial aspect.

To secure even the fragmentary results reported in this monograph required three experimenters and two assistants for the better part of two school years. Of course, we did not use the best technique to begin with, and in our present experiments we are using our time more efficiently, but about all this means is that we are extending somewhat the range of the things we are investigating. It is certainly safe to say that our problems are increasing much more rapidly than our experimental efficiency. The time is past when it is possible to gather together a basketful of toys,

enter the nursery, and with the help of a nurse and such babies as happen to be unengaged, carry on a set of experiments which are at all significant. This is not meant to belittle the work which has been done. It only means that the investigation of human behavior now seems to be starting in earnest. We can no longer throw the burden of adjustment upon some convenient psychical factor which is gradually making its appearance. Our problem is now that of describing the stages through which the infant passes in becoming a participating unit in a social organization. The fact that the infant does not seem to have much to begin with simplifies the problem in one sense. It means that each one of the thousands of more or less socially differentiated activities which make up the personal, domestic, public, vocational, and recreational activities of the individual of the group and of a nation will need to be regarded as special problems for the psychologist. As experimentation progresses, generalizations will be established which will simplify the experimental program; but this will be a slow process.

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